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# ATIONAL
# ELECTRIC LIGHT
# ASSOCIATION

*Twenty-fifth Convention*
*Cincinnati, Ohio*
*May 20, 21, 22, '02*

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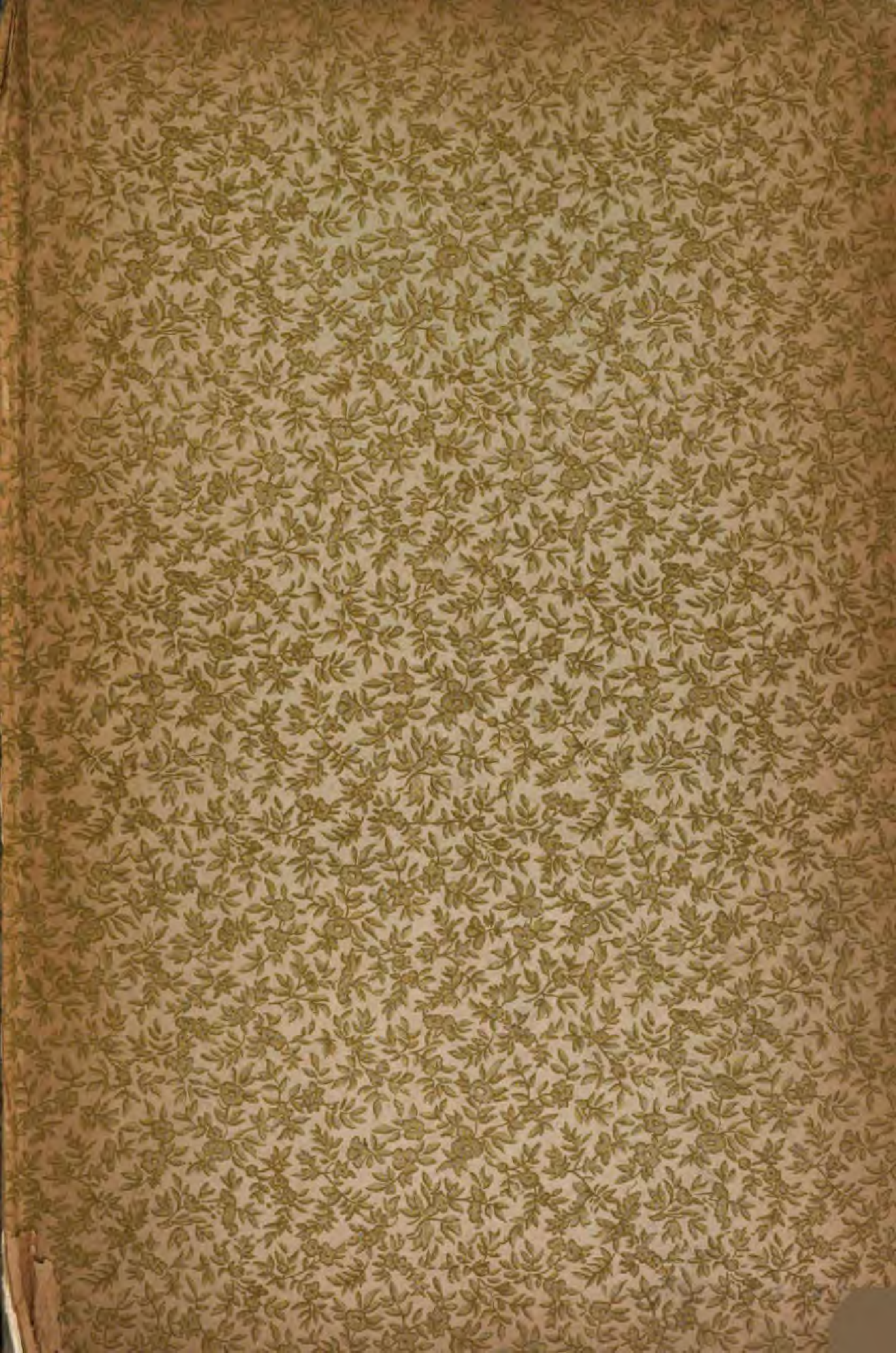

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Henry L Doherty

# NATIONAL
# Electric Light
# ASSOCIATION

## TWENTY-FIFTH CONVENTION

CINCINNATI, OHIO
May 20th, 21st, 22d, 1902

Published by Order of the Executive Committee

NEW YORK
THE JAMES KEMPSTER PRINTING COMPANY
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| *Third* | Baltimore, February 10, 11, 12, 1886 |
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| *Fifth* | Philadelphia, February 15, 16, 17, 1887 |
| *Sixth* | Boston, August 9, 10, 11, 1887 |
| *Seventh* | Pittsburg, February 21, 22, 23, 1888 |
| *Eighth* | New York, August 29, 30, 31, 1888 |
| *Ninth* | Chicago, February 19, 20, 21, 1889 |
| *Tenth* | Niagara Falls, August 6, 7, 8, 1889 |
| *Eleventh* | Kansas City, February 11, 12, 13, 14, 1890 |
| *Twelfth* | Cape May, August 19, 20, 21, 1890 |
| *Thirteenth* | Providence, February 17, 18, 19, 1891 |
| *Fourteenth* | Montreal, September 7, 8, 9, 10, 1891 |
| *Fifteenth* | Buffalo, February 23, 24, 25, 1892 |
| *Sixteenth* | St. Louis, February 28, March 1, 2, 1893 |
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| *Eighteenth* | Cleveland, February 19, 20, 21, 1895 |
| *Nineteenth* | New York, May 5, 6, 7, 1896 |
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| *Twenty-first* | Chicago, June 7, 8, 9, 1898 |
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| LEXINGTON, | Lexington Railway Company |
| LOUISVILLE, | Louisville Electric Light Company |
| MADISONVILLE, | Bailey Light and Water Company |

## LOUISIANA

| | |
|---|---|
| NEW ORLEANS, | New Orleans and Carrollton Railway, Light and Power Company |

## MAINE

| | |
|---|---|
| BANGOR, | Public Works Company |
| PORTLAND, | Portland Lighting and Power Company |
| WATERVILLE, | Waterville and Fairfield Railway and Light Company |

## MARYLAND

| | |
|---|---|
| BALTIMORE, | United Electric Light and Power Company |

## MASSACHUSETTS

| | |
|---|---|
| AMHERST, | Amherst Gas Company |
| ATTLEBORO, | Attleboro Steam and Electric Company |
| BEVERLY, | Beverly Gas and Electric Company |
| BOSTON, | Edison Electric Illuminating Company of Boston |
| BROCKTON, | Edison Electric Illuminating Company of Brockton |
| BROOKLINE, | Brookline Gas Light Company |
| CAMBRIDGE, | Cambridge Electric Light Company |
| COHASSET, | Cohasset Electric Company |
| FALL RIVER, | Fall River Electric Lighting Company |
| FITCHBURG, | Fitchburg Gas and Electric Company |
| GARDNER, | Gardner Electric Light Company |
| LAWRENCE, | Lawrence Gas Company |
| LEE, | Lee Electric Company |
| LOWELL, | Lowell Electric Light Corporation |
| MALDEN, | Malden Electric Company |
| MARLBORO, | Marlborough Electric Company |
| NEW BEDFORD, | New Bedford Gas and Edison Light Company |
| NEWTON, | Newton and Watertown Gas Light Company |
| PITTSFIELD, | Pittsfield Electric Company |
| PLYMOUTH, | The Plymouth Electric Light Company |
| REVERE, | Suburban Gas and Electric Company |
| SPRINGFIELD, | United Electric Light Company |
| SOUTHBRIDGE, | Andrew F. Hall |
| WESTBORO, | Westboro Gas and Electric Company |
| WEST SOMERVILLE, | Somerville Electric Light Company |
| WHITMAN, | Whitman Light and Power Company |
| WINCHENDON, | Winchendon Electric Light and Power Company |
| WOBURN, | Woburn Light, Heat and Power Company |
| WORCESTER, | Worcester Electric Light Company |

## MICHIGAN

| | |
|---|---|
| ADRIAN, | Electric Light and Power Company, Limited |
| ANN ARBOR, | Washtenaw Light and Power Company |
| CORUNNA, | Shiawassee Light and Power Company |
| DETROIT, | Peninsular Electric Light Company |
| EATON RAPIDS, | Citizens' Electric Company |
| HOUGHTON, | Peninsula Electric Light and Power Company |
| IONIA, | Ionia Electric Company |
| JACKSON, | Jackson Light and Power Company |
| SAGINAW, | Bartlett Illuminating Company |
| ST. JOSEPH, | St. Joseph and Benton Harbor Electric Railway and Light Company |

## MINNESOTA

| | |
|---|---|
| ALBERT LEA, | Albert Lea Light and Power Company |
| CROOKSTON, | Crookston Water Works, Power and Light Company |

## MINNESOTA—*Continued*

| | |
|---|---|
| Duluth, | Duluth General Electric Company |
| Little Falls, | Morrison County Electric Light, Heat and Power Company |
| Minneapolis, | Minneapolis General Electric Company |
| Pipestone, | Pipestone Light, Heat and Power Company |
| Red Wing, | Red Wing Gas and Electric Company |
| St. Paul, | Edison Electric Light and Power Company |
| Winona, | Winona Railway and Light Company |

## MISSISSIPPI

| | |
|---|---|
| Aberdeen, | J. F. Enderlin Electric Light Company |
| Columbus, | Columbus Light and Power Company |
| Meridian, | Meridian Railway and Light Company |

## MISSOURI

| | |
|---|---|
| De Soto, | Consumers' Electric Light and Power Company |
| Joplin, | Southwest Missouri Light Company |
| Kansas City, | Kansas City Electric Light Company |
| Macon, | Northwest Electric Light, Heat and Power Company |
| Monett, | Monett Electric Light, Power and Ice Company |
| St. Louis, | Union Electric Light and Power Company<br>Laclede Gas Company |

## MONTANA

| | |
|---|---|
| Anaconda, | Anaconda Copper Mining Company, Electric Light and Railway Department |
| Billings, | Billings Water Power Company |
| Butte, | Butte Light and Power Company |
| Great Falls, | Boston and Great Falls Electric Light and Power Company |
| Kalispell, | Big Fork Electric Power and Light Company |

## NEBRASKA

| | |
|---|---|
| Lincoln, | Lincoln Gas and Electric Company |
| Omaha, | New Omaha Thomson-Houston Electric Light Company |

## NEW HAMPSHIRE

| | |
|---|---|
| Concord, | Concord Electric Company |
| Dover, | United Gas and Electric Company |
| Franklin Falls, | Franklin Light and Power Company |
| Keene, | Keene Gas Light Company |
| Manchester, | Manchester Traction, Light and Power Company |
| Nashua, | Nashua Light, Heat and Power Company |
| Newport, | Newport Electric Light Company |
| Portsmouth, | Rockingham County Light and Power Company |

## NEW JERSEY

| | |
|---|---|
| Atlantic City, | Atlantic Electric Light and Power Company |
| Elizabeth, | United Electric Company of New Jersey |

## NEW JERSEY—*Continued*

| | |
|---|---|
| Hackensack, | The Gas and Electric Company of Bergen County |
| Hammonton, | Electric Light, Heat and Power Company |
| Jersey City, | United Electric Company of New Jersey |
| Lambertville, | Hunterdon Electric Company |
| Long Branch, | Consolidated Gas Company of New Jersey |
| Morristown, | United Electric Company of New Jersey |
| Newark, | United Electric Company of New Jersey |
| Paterson, | Paterson and Passaic Gas and Electric Company |
| Plainfield, | Plainfield Gas and Electric Company |
| Trenton, | South Jersey Gas, Electric and Traction Company |

## NEW YORK

| | |
|---|---|
| Albion, | Albion Power Company |
| Batavia, | Consolidated Gas and Electric Company |
| Auburn, | Auburn Light, Heat and Power Company |
| Brooklyn, | Edison Electric Illuminating Company of Brooklyn |
| Buffalo, | Buffalo General Electric Company |
| Elmira, | Elmira Water, Light and Railroad Company |
| Far Rockaway, | Queens Borough Gas and Electric Company |
| Fishkill-on-Hudson | Citizens' Railroad, Light and Power Company |
| Fulton, | Fulton Light, Heat and Power Company |
| Gloversville, | Fulton County Gas and Electric Company |
| Greenwich, | Consolidated Electric Company |
| Hoosick Falls, | Hoosick Falls Electric Company |
| Kingston, | Kingston Electric Company |
| Lyons, | Wayne County Electric Company |
| Mount Vernon, | Westchester Lighting Company |
| Newburgh, | Newburgh Light, Heat and Power Company |
| New York City, | Henry L. Doherty |
| | The New York Edison Company |
| | United Electric Light and Power Company |
| Niagara Falls, | Buffalo and Niagara Falls Electric Light and Power Company |
| | Niagara Falls Hydraulic Power and Manufacturing Company |
| | The Niagara Falls Power Company |
| Nyack, | Rockland Light and Power Company |
| Norwich, | Norwich Gas and Electric Company |
| Oneida, | Madison County Gas and Electric Company |
| Oneonta, | Oneonta Light and Power Company |
| Potsdam, | Potsdam Electric Light and Power Company |
| Poughkeepsie, | Poughkeepsie Electric Light and Power Company |
| Richfield Springs, | Richfield Springs Electric Light and Power Company |
| Rochester, | Citizens' Light and Power Company |
| | Rochester Gas and Electric Company |
| Roslyn, | Nassau Light and Power Company |
| Schenectady, | Schenectady Illuminating Company |
| Syracuse, | Syracuse Lighting Company |

## NEW YORK—*Continued*

| | |
|---|---|
| TONAWANDA, | Tonawanda Power Company |
| TUXEDO, | Tuxedo Electric Light Company |
| UTICA, | The Utica Gas and Electric Company |
| WATERTOWN, | Watertown Electric Light Company |

## NORTH CAROLINA

| | |
|---|---|
| ASHEVILLE, | Asheville Electric Company |
| ELIZABETH CITY, | Electric Light Company of Elizabeth City |
| RALEIGH, | Raleigh Electric Company |
| SOUTHERN PINES, | Biscoe Electric Light Plant |

## OHIO

| | |
|---|---|
| AKRON, | The Northern Ohio Traction Company |
| CANTON, | Canton Light, Heat and Power Company |
| CINCINNATI, | The Cincinnati Gas and Electric Company |
| CLEVELAND, | Cleveland Electric Illuminating Company |
| COLUMBUS, | Columbus Edison Electric Light Company |
| LANCASTER, | The Lancaster Electric Light Company |
| LEIPSIC, | Leipsic Electric Light, Heat and Power Company |
| PORTSMOUTH, | Portsmouth Street Railroad and Light Company |
| SALEM, | Salem Electric Light and Power Company |
| SPRINGFIELD, | Springfield Light and Power Company |
| TOLEDO, | Toledo Consolidated Electric Company |
| WARREN, | Warren Light and Power Company |
| YOUNGSTOWN, | Youngstown Consolidated Gas and Electric Company |
| ZANESVILLE, | The Zanesville Electric Light Company |

## ONTARIO

| | |
|---|---|
| LONDON, | London Electric Company |
| OTTAWA, | The Ottawa Electric Company |

## OREGON

| | |
|---|---|
| ASHLAND, | Ashland Electric Power and Light Company |
| MARSHFIELD, | Marshfield Lighting Company |
| PORTLAND, | Portland General Electric Company |
| SUMPTER, | Robert E. Strahorn |

## PENNSYLVANIA

| | |
|---|---|
| ALTOONA, | The Edison Electric Illuminating Company of Altoona |
| BELLEVUE, | Ohio Valley Electric Company |
| BETHLEHEM, | Bethlehem Electric Light Company |
| BRADFORD, | Bradford Electric Light and Power Company |
| BRISTOL, | Bristol Electric Light and Power Company |
| CARBONDALE, | Lackawanna Valley Electric Light and Power Supply Company |
| CARLISLE, | Carlisle Gas and Water Company |
| CONNELLSVILLE, | The Electric Company |
| DANVILLE, | Standard Electric Light Company |
| DOYLESTOWN, | Doylestown Electric Company |

## PENNSYLVANIA—*Continued*

| | |
|---|---|
| Easton, | Easton Power Company |
| Erie, | The Erie Company |
| Franklin, | Franklin Electric Company |
| Lewistown, | Lewistown Electric Light Company |
| Manheim, | Lancaster Valley Electric Light Company |
| Morton, | Faraday Heat, Power and Light Company |
| New Castle, | New Castle Electric Company |
| Oil City, | Citizens' Light and Power Company |
| Philadelphia, | Southern Electric Light Company |
| | The American Railways Company |
| | The Brush Electric Light Company |
| | The Electric Company of America |
| Reading, | Metropolitan Electric Company |
| Scranton, | Scranton Illuminating, Heat and Power Company |
| Washington, | Washington Electric Light and Power Company |
| Waynesboro, | Waynesboro Electric Light and Power Company |
| Waynesburg, | Waynesburg Electric Light and Power Company |
| West Chester, | Edison Electric Illuminating Company |
| Williamsport, | Lycoming Electric Company |
| York, | Edison Electric Light Company |

## QUEBEC

| | |
|---|---|
| Montreal, | Lachine Rapids Hydraulic and Land Company |
| | Montreal Light, Heat and Power Company |
| Quebec, | Quebec-Jacques-Cartier Electric Company |
| | Quebec Railway, Light and Power Company |
| | The Canadian Electric Light Company |

## RHODE ISLAND

| | |
|---|---|
| Pawtucket, | Pawtucket Electric Company |
| Providence, | Narragansett Electric Lighting Company |
| Woonsocket, | Woonsocket Electric Machine and Power Company |

## SOUTH CAROLINA

| | |
|---|---|
| Columbia, | Columbia Street Railway, Light and Power Company |

## SOUTH DAKOTA

| | |
|---|---|
| Lead, | Belt Light and Power Company |

## TENNESSEE

| | |
|---|---|
| Chattanooga, | Chattanooga Light and Power Company |
| Knoxville, | Knoxville Traction Company |
| Memphis, | Memphis Light and Power Company |
| Nashville, | Cumberland Electric Light and Power Company |

## TEXAS

| | |
|---|---|
| Corsicana, | Corsicana Gas and Electric Company |
| El Paso, | El Paso Electric Company |
| San Antonio, | San Antonio Gas and Electric Company |

## VERMONT

| | |
|---|---|
| BELLOWS FALLS, | The Fall Mountain Electric Light and Power Company |
| BENNINGTON, | Bennington Water Power and Light Company |
| FAIR HAVEN, | Fair Haven Electric Company |
| MIDDLEBURY, | Middlebury Electric Company |
| MONTPELIER, | Consolidated Lighting Company |
| RUTLAND, | Rutland City Electric Company |

## VIRGINIA

| | |
|---|---|
| LYNCHBURG, | Lynchburg Traction and Light Company |
| RICHMOND, | Virginia Passenger and Power Company |
| | Virginia Electrical Railway and Development Company |
| ROANOKE, | Roanoke Railway and Electric Company |

## WASHINGTON

| | |
|---|---|
| DAYTON, | Dayton Electric Light and Power Company |
| EVERETT, | Everett Railway and Electric Company |
| HOQUIAM, | North Shore Electric Company |
| SEATTLE, | Seattle Electric Company |
| | Snoqualmie Falls Power Company |
| WALLA WALLA, | Walla Walla Gas and Electric Company |

## WEST VIRGINIA

| | |
|---|---|
| WHEELING, | Wheeling Electrical Company |

## WISCONSIN

| | |
|---|---|
| ANTIGO, | Antigo Electric Light Plant |
| FOND DU LAC, | Fond du Lac Street Railway and Light Company |
| JANESVILLE, | Janesville Electric Company |
| KENOSHA, | Kenosha Gas and Electric Company |
| LA CROSSE, | Edison Light and Power Company |
| MADISON, | Madison Gas and Electric Company |
| MENOMONIE, | Menomonie Electric Light and Power Company |
| OCONTO, | W. A. Holt |
| RHINELANDER, | Rhinelander Lighting Company |

# ASSOCIATE MEMBERS.

| | |
|---|---|
| Auburn, N. Y., | McIntosh, Seymour and Company |
| Baltimore, Md., | Electrical Material Company |
| Boston, Mass., | Albert and J. M. Anderson |
| | American Circular Loom Company |
| | Frank Ridlon Company |
| | Pettingell-Andrews Company |
| Bridgeport, Conn., | Bryant Electric Company |
| Chicago, Ill., | Electric Appliance Company |
| | The Stirling Company |
| | Western Electric Company |
| | *Western Electrician* |
| Cincinnati, O., | Bullock Electric Manufacturing Company |
| Cleveland, O., | National Carbon Company |
| | The United States Carbon Company |
| Dayton, O., | National Cash Register Company |
| Fostoria, O., | Crouse-Tremaine Carbon Company |
| Hartford, Conn., | Electric Vehicle Company |
| La Plata, Argentine Republic, | Frank Cassels |
| Lockport, N. Y., | American District Steam Company |
| Newark, N. J., | Baker and Company |
| | The C. McIntire Company |
| | Weston Electrical Instrument Company |
| New York City, | *American Electrician* Company |
| | Bryan-Marsh Company |
| | Day's Kerite |
| | Elblight Company of America |
| | *Electrical Review* Publishing Company |
| | *Electricity* Newspaper Company |
| | Evans, Almirall and Company |
| | Franklin H. Kalbfleisch Company |
| | General Electric Company |
| | General Incandescent Arc Light Company |
| | Gould Storage Battery Company |
| | Hugo Reisinger |
| | H. W. Johns Manufacturing Company |
| | India Rubber and Gutta Percha Insulating Company |
| | John A. Roebling's Sons Company |
| | Manhattan General Construction Company |
| | Manhattan Electrical Supply Company |

| | |
|---|---|
| NEW YORK CITY, | Monarch Fire Appliance Company |
| | National Conduit and Cable Company |
| | New York Insulated Wire Company |
| | Osborn Flexible Conduit Company |
| | Rossiter, MacGovern and Company |
| | Safety Insulated Wire and Cable Company |
| | Sprague Electric Company |
| | Standard Paint Company |
| | The Dale Company |
| | *The Electrical World and Engineer* |
| | The Okonite Company |
| | The Phœnix Glass Company |
| PHILADELPHIA, PA., | Alfred F. Moore |
| | Electric Storage Battery Company |
| PITTSBURG, PA., | Nernst Lamp Company |
| | Standard Underground Cable Company |
| | Westinghouse Electric and Manufacturing Company |
| PITTSFIELD, MASS., | Stanley Electric Manufacturing Company |
| PROVIDENCE, R. I., | American Electrical Works |
| | New England Butt Company |
| ST. CATHERINES, ONT., | The Packard Electric Company, Limited |
| ST. LOUIS, MO., | Columbia Incandescent Lamp Company |
| SPRINGFIELD, MASS., | Munder Electrical Works |
| SYRACUSE, N. Y., | Pass and Seymour |
| WARREN, O., | New York and Ohio Company |
| WORCESTER, MASS., | John P. Coghlin |

# OFFICERS AND EXECUTIVE COMMITTEE

### *Officers*

| | |
|---|---|
| Henry L. Doherty | President |
| Louis A. Ferguson | First Vice-President |
| Charles B. Hunt | Second Vice-President |
| George F. Porter | Secretary and Treasurer |
| C. O. Baker, Jr. | Master of Transportation |

### *Executive Committee*

Elected at the Twenty-second to serve until the close of the Twenty-fifth Convention

Edward F. Peck
William M. Brock
Charles E. Scott

Elected at the Twenty-third to serve until the close of the Twenty-sixth Convention

Charles B. Hunt
Henry L. Doherty
Ernest H. Davis

Elected at the Twenty-fourth to serve until the close of the Twenty-sixth Convention

Dudley Farrand (in place of Charles B. Hunt, promoted)
E. L Bemiss (in place of Henry L. Doherty, promoted)

Elected at the Twenty-fourth to serve until the close of the Twenty-seventh Convention

Charles L. Edgar
C. C. Howell
D. P. Robinson

Elected at the Twenty-fifth to serve until the close of the Twenty-sixth Convention

Arthur Williams (in place of Ernest H. Davis, promoted)

Elected at the Twenty-fifth to serve until the close of the Twenty-seventh Convention

J. H. Perkins (in place of Charles L. Edgar, promoted)
C. F. Hewitt (in place of C. C. Howell, deceased)

Elected at the Twenty-fifth to serve until the close of the Twenty-eighth Convention

A. C. Dunham
P. G. Gossler
H. T. Hartman

# COMMITTEES

## TO REPORT TO THE TWENTY-FIFTH CONVENTION

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### *Committee on Finance*

H. H. Fairbanks, Chairman

| | |
|---|---|
| W. S. Barstow | E. F. Peck |

### *Committee on Standard Rules for Electrical Construction and Operation*

William Brophy, Chairman

| | |
|---|---|
| James I. Ayer | C. L. Edgar |

### *Committee on Standard Candle Power of Incandescent Lamps*

Dr. Louis Bell, Chairman

| | |
|---|---|
| James I. Ayer | Calvin W. Rice |

### *Committee on Legislation Regarding Theft of Current*

W. F. Douthirt

### *Committee on Amendments to Freight Classification on Electrical Apparatus and Goods*

James I. Ayer, Chairman

| | |
|---|---|
| W. C. Bryant | Geo. W. Davenport |

### *Committee on Legislative Policy*

Samuel Insull, Chairman

| | |
|---|---|
| H. M. Atkinson | Samuel Scovil |
| Ernest H. Davis | Charles R. Huntley |

### *Committee on Photometric Values of Arc Lamps*

Henry L. Doherty, Chairman

| | |
|---|---|
| Professor W. Elwell Goldsborough | J. Q. Brown |

### *Committee on Amendments to By-Laws*

Samuel Insull, Chairman

| | |
|---|---|
| W. Worth Bean | Charles B. Hunt |
| Ernest H. Davis | Henry L. Doherty |

Louis A. Ferguson

### *Committee on Analysis of Flue Gases*

Henry L. Doherty, Chairman

| | |
|---|---|
| W. L. Abbott | Dugald Jackson |

### *Committee on Uniform Accounting*

G. E. Tripp, Chairman

| | |
|---|---|
| W. F. Ham | W. A. Anthony |

# COMMITTEES

## TO REPORT TO THE TWENTY-SIXTH CONVENTION

*Committee on Finance*

H. H. Fairbanks, Chairman

W. S. Barstow
Edward F. Peck

*Committee on Standard Rules for Electrical Construction and Operation*

William Brophy, Chairman

James I. Ayer
Charles L Edgar

*Committee on Standard Candle Power of Incandescent Lamps*

Dr. Louis Bell, Chairman

James I. Ayer
Calvin W. Rice

*Committee on Amendments to Freight Classification on Electrical Apparatus and Goods*

James I. Ayer, Chairman

W. C. Bryant
George W. Davenport

*Committee on Legislative Policy*

Samuel Insull, Chairman

H. M. Atkinson
Samuel Scovil
Ernest H. Davis
Charles R. Huntley

*Committee on Photometric Values of Arc Lamps*

Henry L. Doherty, Chairman

Professor W. Elwell Goldsborough
Professor Charles P. Matthews

*Committee on Analysis of Flue Gases*

Henry L. Doherty, Chairman

W. L. Abbott
Dugald Jackson

*Committee on Uniform Accounting*

G. E. Tripp, Chairman

W. F. Ham
W. A. Anthony

*Committee on Relations Between Manufacturers and Central Station Companies*

Charles L. Edgar, Chairman

Henry L. Doherty
A. C. Dunham

# ORDER OF BUSINESS

TUESDAY, May 20th, 1902.

### FIRST SESSION, 10.15 A. M.

1. Address of Welcome. By General Andrew Hickenlooper
2. Announcements
3. Address of President Doherty
4. Executive Session

### SECOND SESSION, 2.10 P. M.

1. Paper—"Does It Pay to Creosote Wooden Poles for Electric Line Work?" By W. E. MOORE
2. Discussion—"What Efficiency Lamp Should Be Used, and How May This Efficiency Be Determined for Any Particular Station?" HENRY L. DOHERTY, S. E. DOANE, L. G. VAN NESS, FRANCIS W. WILLCOX, CONVERSE D. MARSH

### THIRD SESSION, 8.10 P. M.

1. Paper—"The Taking Caring of Consumers' Complaints." By IRVIN BUTTERWORTH
2. Paper—"What Changes Should Be Made in the Plan of Uniform Accounting?" By J. P. CROWLEY
3. Discussion—"Are Loose-Leaf Ledgers Desirable for Electric Companies' Records?" G. E. TRIPP, H. H. FAIRBANKS, GEORGE W. DAVENPORT, CHARLES R. PRICE

# MINUTES

## OPENING OF THE CONVENTION

The association convened at the Grand Hotel, Cincinnati, Ohio, Tuesday morning, May 20th, 1902, and was called to order by President Doherty at a quarter after ten o'clock.

THE PRESIDENT: Gentlemen, I have the pleasure of introducing General Andrew Hickenlooper, president of the Cincinnati Gas and Electric Company, who will welcome us to the city of Cincinnati. I have had the pleasure of attending a number of functions in Cincinnati as the guest of the Cincinnati Gas and Electric Company, and we have always had a very warm welcome, and have found a very agreeable host in General Hickenlooper.

General Hickenlooper then read the following

## ADDRESS OF WELCOME

*Gentlemen of the National Electric Light Association:*

It affords me pleasure to acknowledge the compliment of being assigned to the agreeable duty of extending, on behalf of our citizens and your resident fellow craftsmen, a cordial and heartfelt welcome to

> "The Queen City of the West, in her garlands dressed,
> On the banks of the beautiful river."

Our city, within her territorial and tributary limits, embraces a population of nearly half a million people, two hundred thousand of whom are directly engaged in manufacturing enterprises, turning out every year products valued at three hundred millions of dollars, which find their way, over twenty centering lines of railways, to every section of the habitable globe. It contains the largest soap works, the biggest tannery, the most extensive lithographing establishment, the greatest shoe industries, and the largest number of carriage factories of any city in the world.

Last, but not least, our city contains one of the best-equipped and most efficiently managed electric manufacturing plants in this country, which, based upon its past history and phenomenal growth, gives promise of taking its place in the near future in the front rank of the great electrical industries of our country. From the mere nucleus of a plant employing but twenty men in 1896, it has in this brief period of half a dozen years grown to the dimensions you will be afforded an opportunity of inspecting; briefly stated, having ultimately a producing capacity of 10,000-kilowatt machines and furnishing employment to 800 men.

Not only do we thus point with pride to our various manufacturing enterprises, but we take equal pleasure in calling your attention to the beauties of our suburban residence districts; to our incomparable zoological gardens; to our Music Hall, our Art Museum and Rookwood pottery; to our Cincinnati University, our high-school buildings, and other notable structures, the erection of which was made possible by the munificent bequests of McMicken, Springer, West, Woodward, Hughes, Cunningham, and other enterprising and public-spirited citizens, who by such commendable acts have endeared their names to every inhabitant of our city.

To you, gentlemen, who honor us with your presence, it is unnecessary to say more than to refer briefly to the pleasure we feel in extending this welcome to men who have by their energy, genius and scientific attainments rivaled the accomplishments of Aladdin, with whose phenomenal success in the lamp business it is presumed you are all still more or less familiar. But in order that you may not claim an exclusive patent on his business methods, or arrogate to yourselves all the credit for success in "changing new lamps for old ones," I desire to call your especial attention to the fact that even in his case it became necessary to enlist the services of two promoting agencies—the "Genius of the Lamp," which you may properly represent, and the "Genius of the Ring," a term not infrequently locally applied to gentlemen like myself, who have rendered material assistance in promoting the introduction and utilization of the appliances that your genius has created.

It has been said of the immortal Lincoln that for a time "he forged the thoughts that governed the world." You, gentlemen, have not only forged the thoughts, but have moulded into practical shape the crude ideas of others, and have made possible their application to industrial pursuits and business enterprises that have enriched the world and added materially to the comfort and happiness of mankind.

It is not my purpose to weary you with words of fulsome praise, but only to voice as briefly as possible the sentiments of all thinking people who recognize the fact that you have established for yourselves reputations for ability, energy, integrity, and that type of manhood that marks each and every member of your association as distinctive characters of an age which in scientific accomplishments stands unparalleled in the world's history.

We sincerely hope that this, your twenty-fifth meeting, may prove no less enjoyable and professionally profitable than those that have preceded it; and when you have finally exchanged all your new lamps and ideas for our old ones, and leave for your distant fields of labor, we trust that each and every one may carry with him naught but pleasant memories of your only too brief visit to our city.

MR. FREDERIC NICHOLLS: Mr. President, and fellow members of the National Electric Light Association: Your president has asked me to return thanks to General Hickenlooper for his very cordial address of welcome to the members of the National Electric Light Association here assembled. I have been asked to be brief, and I will heed the request. At the same time, sir, I wish to say, in response to this address of welcome (and I think I have some means of knowing, as I have been at nearly every meeting of this association since its inception), that I have never seen a programme at any previous convention that gave such promise of accomplishing so much for the benefit of the electrical industry in general; and after listening to the cordial welcome from General Hickenlooper I am ready to say that I do not believe we have ever assembled in convention in any other city where we have been promised so great and so varied an entertainment. I am sure I look forward with great pleasure, personally, to spending the next few days in this city, and I am sure that each and all of us will go away with higher ideas in regard to the city and with grateful recollections of the enjoyment we have had during our stay; and that we shall also go away feeling that we have learned a great deal in our chosen profession after listening to the splendid programme that has been prepared by our president and the executive committee of this association.

General Hickenlooper, I have much pleasure in extending to you on behalf of the association a cordial vote of thanks for your hearty welcome to the members of the association.

# ANNOUNCEMENTS

Letters of regret from the following members were then read:

"New York, April 22d, 1902.

"Mr. Henry L. Doherty,
"President National Electric Light Association,
"136 Liberty Street, New York.

"Dear Sir: Acknowledging your courteous invitation dated April 7th, I wish to thank you for your kind thought. I am following with sympathetic interest the efforts of the association, and regret very much that urgent duties, to which I must attend, make it impossible for me to participate in them actively.

"With best wishes for the success of the coming meeting, I remain

"Yours very truly,
"N. Tesla."

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"Lynn, Mass., May 5th, 1902.

"Mr. Henry L. Doherty,
"President National Electric Light Association,
"136 Liberty Street, New York.

"Dear Sir: I wish to acknowledge the receipt of your kind invitation to be present at the twenty-fifth convention of the National Electric Light Association, at Cincinnati, May 20–22. I hardly think I shall be able to make the trip at that time, as my engagements are likely to interfere.

"Thanking you for your courtesy, I am

"Very truly yours,
"Elihu Thomson."

"34 GREAT GEORGE STREET,
"WESTMINSTER, S. W., April 17th, 1902.

"HENRY L. DOHERTY, ESQ.,
"President National Electric Light Association,
"New York.

"DEAR SIR: Your very kind invitation to the convention of your association to be held at Cincinnati, May 20–22, has reached me on my return from a voyage abroad.

"While thanking you for the honor you have done me, I regret that I cannot leave England again at present and must therefore decline your most kind invitation.

"Believe me, dear sir,

"Most cordially yours,

"GEORGE FORBES."

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"CORNELL UNIVERSITY,
"ITHACA, N. Y., April 9th, 1902.

"MR. HENRY L. DOHERTY,
"President National Electric Light Association,
"New York.

"DEAR MR. DOHERTY: I have the honor to acknowledge the receipt of your invitation to be present at the twenty-fifth convention of the National Electric Light Association, to be held at Cincinnati, May 20th, 1902. I regret that my duties here will probably make it impossible for me to attend. I greatly enjoyed the meeting at Niagara Falls, and should esteem it a privilege to be present at the coming convention.

"Yours very truly,

"EDW. L. NICHOLS."

"McGill University,
"Montreal, April 30th, 1902.

"Henry L. Doherty, Esq.,
"President National Electric Light Association,
"New York, U. S. A.

"Dear Sir: I have postponed replying to your kind invitation of April 7th until now, hoping that I might be fortunate enough to see my way clear to accept it. I regret, however, that I find that it will be impossible to do so, as my engagements in the east and west of Canada will occupy me very largely during the months of May and June.

"Thanking you for your courtesy,

"Believe me to remain
"Yours very truly,
"Henry T. Bovey."

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"Crompton Laboratory,
"Kensington Court, London, W.,
"April 21st, 1902.

"Henry L. Doherty, Esq.,
"President National Electric Light Association,
"New York.

"Dear Sir: I feel greatly honored by your kind invitation to be present at the twenty-fifth convention of your association, at Cincinnati, Ohio, on May 20th, but I regret that on account of my being at present attached to the staff of the War Office of this country I am not able to avail myself of your invitation, as I cannot leave England for some months to come.

"Thanking you, I remain

"Yours very faithfully,
"R. E. Crompton,
"Lieutenant-Colonel R. E"

"TREASURY DEPARTMENT,
"NATIONAL BUREAU OF STANDARDS,
"WASHINGTON, May 1st, 1902.

"MR. GEO. F. PORTER,
"Secretary National Electric Light Association,
"New York City.

"DEAR SIR: I beg to acknowledge receipt of your invitation to attend the twenty-fifth convention of the National Electric Light Association, to be held at Cincinnati, May 20–22.

"It gives me pleasure to state that either myself or a representative of this Bureau will be present at the meeting, and will make a statement as to the progress and future development of the Bureau. We should also be pleased to have suggestions from the National Electric Light Association, as it is our desire to co-operate with such bodies in every possible case.

"Respectfully,
"S. W. STRATTON,
"Director."

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"WAUPACA, WIS., May 3d, 1902.

"MR. GEO. F. PORTER,
"Secretary National Electric Light Association,
"New York City.

"DEAR SIR: Please convey to Mr. Henry L. Doherty, president of the National Electric Light Association, my thanks for his courtesy in extending to me an invitation to attend the twenty-fifth convention of the association, to be held at Cincinnati, May 20–22.

"It will be impossible for me to say at this time whether it will be possible for me to be present or not. If circumstances are such that I can get away I shall be only too glad to be with you.

"With personal regards to your president, and best wishes for the National Electric Light Association, I remain

"Yours truly,

"IRVING P. LORD,

"President Northwestern Electrical Association."

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THE PRESIDENT: Gentlemen, before going on with the regular programme I have a few announcements to make. The first is in regard to calling the meetings on time. We have the largest programme to cover that we have ever had at one of our conventions. We cannot finish it unless we attend to business. We must attend strictly to business, and be brief and to the point, and whatever hour is fixed for reconvening will be observed strictly, and the meeting will be called to order exactly at that time. You have it in your hands to fix upon any hour you desire, but whatever hour you fix upon will be adhered to, and the session will be called to order at that time; and I ask the delegates, as a matter of courtesy to the association, and as a matter of courtesy to your officers and to the contributors to the programme, to be here in the convention hall when we convene. It is a hard matter for the gentlemen who are on the programme to talk to empty chairs; it is discouraging.

In preparing our programme I have had to draw largely upon my personal friends. It has been very difficult to get volunteers. Some of those who are on the programme will not be here. It happens that there is a meeting of a gas association in New Orleans on the same date as our meeting here, and there is to be a meeting of the American Society of Mechanical Engineers in Boston next week. Each of these meetings has interfered in a measure with delegates who would otherwise have been at this convention.

I will now read the address that is customary from the presiding officer of this association; but before doing so I want to thank you for the honor you did me in electing me your president. I was not at your last convention and could not thank you then.

President Doherty then read his address, as follows:

## ADDRESS OF PRESIDENT DOHERTY

GENTLEMEN: It is with great pleasure that I refer to the progress made by this association in recent years. Our membership has increased rapidly; we now have a proper income for the support of the association, although a larger income would be very welcome and would enable us to make this association a great factor in the development of the central-station business, which, after all, is the backbone of the entire electrical industry. Not only is our membership growing, but its quality is also improving. We may expect valuable work from our membership, as it possesses untold possibilities; but in some way the necessity must be impressed upon our members for their taking a greater interest in the association's work, and feeling a greater responsibility for association progress.

### PROGRAMME METHODS

The programme presented at this convention will be a radical departure from our former methods. Your officers believe that more satisfactory results can be obtained and greater assistance rendered the central-station industry by the elimination of long papers on technical subjects and the substitution therefor of short written discussions by men in position to give valuable advice on these subjects of practical every-day importance to central station managers. You cannot expect this new departure to develop all of its possibilities upon its first application. It has been almost impossible to obtain the support of our members and to impress upon them just what was wanted. If this programme method proves to be as acceptable to you as was our former method, I am quite sure we shall, within another year, make it of great value, for I believe this plan renders it possible for every member to co-operate better with the association officers. Few men feel inclined to write a long paper on some certain subject, and to present every aspect of the matter under consideration, yet all the companies that are members of this association have officers or men in their employ who can give us valuable information, data or points on problems that must be solved sooner or later by every central station manager. Something must be done to dispel the apathy of our members. They must not only suggest the subjects they wish to have discussed, but must also help the officers in locating men who are capable of discussing them, and must exert their influence to obtain the co-operation of these men, if pressure must be brought to bear to secure their assistance.

Many of the subjects that would naturally be treated in a presidential address will be brought out by discussion, and therefore I will endeavor to anticipate these discussions as little as possible.

### PROGRESS

It is customary to expect the president of your association to detail the progress made in methods and appliances during his administration. I do not think that the qualifications which go to make up a good presiding officer are apt to be the same qualifications as those that would go to make up a man capable of detailing to you this progress. Many of our most aggressive and prominent members are either business men pure and simple, or else their numerous duties occupy so much of their time that they have little or no opportunity for keeping fully posted upon all developments of an engineering nature. I therefore recommend that the association not only elect a president each year, but that they also elect an *editor* to report progress made in methods and apparatus, authorizing this editor to appoint as many sub-reporters as he sees fit to do. This position of editor should be one of much honor, for it is a practical estimate by practical men of their high regard for his ability.

I will not attempt to report progress made in all branches of the central-station business, as I feel incapable of doing so; but I will take occasion here to refer to a few developments which will have the most potent bearing upon this industry.

In general, I may say that the vital portions of central-station work are the beginning and the ending; and the problems that affect us most are those not strictly within the province of electrical engineering. Our present enormous waste, and our greatest opportunity for economy, is in our boilers and engines, or other prime movers that we use; but probably our greatest opportunity for increasing our earnings lies in the development of our market. Recent developments have made it possible to obtain a brake horse-power per pound of coal, by the use of internal combustion engines. This subject will be treated more fully at another session of this convention.

A manufacturer recently gave a bid on a steam turbine, direct-connected to an alternating-current generator, with a guarantee of steam consumption that would be almost equal to 10 pounds of steam per indicated horse-power in our old type engines. The possibilities of steam turbines will also be presented at this convention.

The development of our market is almost a purely commercial problem, yet one incapable of solution without engineering considerations. There is a constant tendency toward the adoption of electricity, which should be properly encouraged. Electric current is finding a wider and wider field for application for power purposes, and the possibilities of development for sign and decorative lighting are almost unlimited. This subject will also be treated at a future session.

The acquisition of this business on a favorable basis depends very largely upon our method of charging, and, in spite of the fact that this subject has been considered and reconsidered at the past four or five conventions of this association, we found that a larger majority of our membership wished to hear this subject discussed than any subject that now confronts central station managers. We have therefore tried to arrange for its thorough discussion, by obtaining written opinions from the advocates of the various systems now in vogue, as a proper introduction of the subject.

## THE PROVINCE OF THIS ASSOCIATION

This association was formed for the benefit of the central-station industry, and its future aim should be to assist central station managers. It must therefore solve all problems that the central station manager is called upon to meet, and these problems are not confined to electrical engineering. We often speak of this as an electrical age, which is a very pretty sentiment, but hardly in accord with facts. Electricity is simply a means for transmitting power, and the economies of the electric-lighting business are even less dependent upon electrical engineering than upon steam engineering and business methods. There seems to be a prevailing belief that this association should be strictly a technical society, but I am confident that if we devoted ourselves entirely to technical matters, it would be detrimental to the central-station industry, and we should be covering a field that should be covered by other associations, and neglecting a field of work which would not then be covered by any association. The central-station business is in an undeveloped state—its possibilities are problematic. There has been no uniform development of individual central stations. Some central stations have been developed to the point where they have wired up an equivalent of nearly two 16-cp lamps per inhabitant and have a revenue of $3.00 to $4.00 per capita. Other central stations have but one 16-cp lamp wired up to every ten inhabitants, and have a revenue of less than fifty cents per capita.

A great mass of the education and information required for the proper development of this business is not at all dependent on technical electrical engineering only, or at least is only incidental thereto; but it is clearly the province of this association to cover the field of central-station work, whether it be the solution of how best to transform heat to power, or how best to acquire business. It would also be of benefit to the entire engineering fraternity if closer relationship could be established between all the societies.

### THE PROPER ATTITUDE TOWARD OTHER ASSOCIATIONS

There is a fine chain of identification extending through all the electrical associations, although there is no well-defined relationship. On one hand we have the Institute of Electrical Engineers, with a large membership capable of best handling all subjects of highly scientific character, and best equipped, from the standpoint of membership, to undertake all work of a research nature. On the other hand we have numerous state and sectional organizations, which are intended to benefit the small central station managers who cannot afford to join our association, or who cannot leave their plants to make any great journey to attend this association's meetings. Now, in a measure we are the connecting link between the Institute of Electrical Engineers and these small electrical associations. These state organizations have a peculiar field of usefulness, and any encouragement that can be offered should be extended to assist in building up these small organizations. We should each year invite the officers of these small associations to our convention, and encourage them to look to us for assistance in matters that are beyond the scope of their own association. These associations should endeavor so to map their work that it does not interfere with the work of this association, but is in harmony therewith; and we in turn should aim to cover a field of work not covered by the Institute of Electrical Engineers, and to have such technical work as is needed for our progress undertaken by the latter body, by joining their organization and having such a large central-station representation that the Institute would give proper consideration to all technical matters relating especially to central-station work. The American Society of Mechanical Engineers also covers a great portion of engineering work that confronts the central station manager, and a closer relationship with this society cannot help but prove beneficial to all parties. I refe now more particularly to our problems in steam engineering.

### THE METRIC SYSTEM

The bad effect of lack of affiliation with other scientific societies is evidenced in the present attitude of these societies on the adoption of the metric system for governmental work. The American Institute of Electrical Engineers has formally adopted resolutions favoring the metric system; the American Society of Mechanical Engineers has taken the opposite position. Personally, I am fully in accord with the former society, and entirely in discord with the latter society and I feel that it has been prompted by selfish reasons to turn back the wheels of progress. It is exasperating to feel that, because a few men have a portion of their assets in standards whose value would be destroyed, we must continue to use a system of weights and measures improperly suited to our needs, which must necessarily curtail the usefulness of engineering labor to such an extent that it is equivalent to shortening the life of every man following engineering work. It is not unfair to assume that our present system of weights and measures is as cumbersome and objectionable when compared with the decimal system of weights and measures as is the English system of currency when compared with our decimal system of currency; and I cannot believe there is any man unbiased by selfish reasons, who has had experience with both systems of currency, who is not firmly convinced that the English people should, to their great advantage, immediately dispense with their present system in favor of the decimal system, even though it result in temporary hardship and inconvenience. Every argument that can be brought in favor of a change from the English system of money to the decimal system, can also be brought in favor of a change from our system of weights and measures to the decimal system of weights and measures. I think the association should give this matter further consideration, and if our membership is as greatly in favor of the decimal system as I believe they are, we should put ourselves on record in such unqualified terms that there can be no further doubt of the position of this association on this question.

### OUR RELATIONSHIP TO MANUFACTURERS

The interests of the central stations of this country and the interests of the manufacturers of the apparatus that we use, are ofttimes identical. In former conventions of this association we have heard frequent criticisms of the fact that papers presented at our meetings often favored a manufacturer of some certain class of apparatus. On the other hand, the rules of this association are so strict that at times we must work a hardship to the manufacturer and curtail the usefulness of the association in order to avoid these criticisms. There can be no distinctive line drawn; and while we cannot permit manufacturers to use our association for advertising purposes, we must leave the matter in a great measure within the discretion of the officers of this association, as to the character of the papers presented and the editing of their contents, and must allow our members to refer to an apparatus or to a manufacturer on the floor of this convention at their discretion. We, of course, reserve the right to eliminate any of their remarks if we think it best to do so, and we should be able to protect ourselves from the abuse of this discretion by censuring any speaker on the floor whose intentions are purely out of accord with the liberty granted him, or by debarring him from further participation in our proceedings. We want the assistance of all the manufacturing companies, and we can reap considerable benefit from their co-operation. In the long run, and on some points especially, our interests are absolutely identical, and yet some manufacturers, by a short-sighted business policy, aim to gain small profits for themselves, at great expense to the central-station industry and the retardation of central-station development, by cultivating competitive conditions.

### MUNICIPAL AND OTHER COMPETITION

No one feature so retards the development of this industry as the fear of competition. This reduces our credit, and without credit, we cannot get money on terms sufficiently advantageous to permit of proper development. Unless the fear of competition can be driven from the minds of capitalists, the central-station business of this country must of necessity drift into the hands of large syndicates, who can protect themselves from the periodical raids that are now made upon the electric business by the organization of new companies for the sake of being bought off, and who can in a measure protect themselves from municipal competition by the average results of a number of plants in different cities. The efforts of the advocates of municipal ownership are productive of the very results which they most seek to avoid, namely, the formation of large syndicates for the control of these properties. I do not regard municipal ownership as a matter of permanent importance. Ninety per cent of all the municipal plants that have been installed have proven rank failures. Many of them have been abandoned, and many others of them would be disposed of if the tax payers really knew the results obtained in these plants. It is idle to suppose that a municipality can ever operate an electric plant as economically as can private capital. The question thus reduces itself to whether we, as central station men, are going to demand profits so large that we force the city to build its own plant, or whether we are content to furnish service at a price equal to what it would cost the city to furnish its own service, depending for our profits upon the greater degree of economy that will be obtained in a privately operated plant. Of course we cannot meet the absurd paper costs that are presented by hare-brained reformers on all sides, but we must meet this municipal ownership fallacy with hard facts and not with wind. Our opponents generally deal only in wind, but pose as friends of the people. If we deal only in wind we are at a disadvantage, for we must necessarily appear as foes to the people. To meet both kinds of competition described above, we must educate the public. We must show the people, before a crisis occurs in any one city, that privately owned opposition plants are most frequently exploited for the purpose of being bought off; and that, even if started with honest motives, they result in consolidation, increasing the capitalization of the original investment, and either cause an advance in price, or prevent reductions which might otherwise be expected and insisted upon from time to time. To meet municipal competition, we must be in position to tell the people what results have been obtained in other cities where this experiment has been tried; but I doubt if we shall ever obtain any data of value except by a thorough investigation, by an expert accountant and a competent engineer, of each municipally operated plant. For us to attempt this work individually would not be as advisable as to join hands with some other organization that is interested in demonstrating that municipally operated plants are a success. The officers of your association made an offer to the League of American Municipalities, at its Syracuse Convention in 1899, to join hands with them for the purpose of making a very thorough investigation of a number of municipal plants. Our offer was backed up with a check for

$2,500 to cover one-half of our portion of the expense. The League has never attempted to meet us half way. A large portion of its membership do not want facts; the remaining small portion are sincere in their belief in municipal ownership, but are so hopelessly in the minority that it is impossible for them to make any effective effort to join with us in this investigation. I recommend that another effort be made to induce the League of American Municipalities either to "put up or shut up." We cannot compel them to make this investigation against their will, but we can prevent them from having any good excuse to offer for not doing so, for if we offer to furnish all of the money necessary for the investigation, there can be no good ground for their still refusing to join us. If they still neglect to join in this investigation, we should make this offer to other similar organizations. The American Economic Society is largely composed of municipal ownership advocates. Their membership comes largely from men of academic profession who have so little knowledge of politics and men that they cannot be expected to know and appreciate the disadvantage and shortcomings of municipal ownership. They may be willing to join us in this investigation, and may even be willing to put up some of the funds, for I believe most of them are sincere in their views. When I speak of the dangers of municipal ownership I do not refer to dishonesty, for I believe that dishonesty in municipal politics is greatly over-rated. I don't think any one need worry about the money that is actually stolen, but places must be found for loyal party men, and selection must be made of superintendents, electricians and employees on a basis of political influence or party, and not on merit. A good workman in a private plant may make a poor workman in a municipal plant, because there is no one to appreciate his work, and because he is often independent of his superiors, as he cannot be removed at their discretion. But what is the use of theorizing on this subject. We may as well deal in facts. Ninety per cent of all the municipal plants established have been failures, and it only remains for true conditions to be demonstrated in the case of the others.

### DEVELOPMENT OF OUR MARKET

We have not yet reached the commercial age, and I predict that within five years the members of our association will almost lose sight of engineering matters in their eagerness to increase their sales. Our earnings through economy of operation have well-defined limits, but the possibilities of increasing our earnings by developing our market have a much wider range. About 70 per cent of all our expenses are not influenced by the output of our station, and are only partially influenced by the capacity of our station. We sell only from 10 per cent to 30 per cent of the amount of current we are capable of generating, and our plants therefore lie practically idle about 70 per cent to 90 per cent of the time. It is not possible to acquire a daily uniform load, but we can greatly influence the load factor of our stations by the class of business that we encourage. We want that class of business which demands the least investment, and which yields the greatest consumption. I think we must lessen the difference between our operating costs and selling price. It is possible to make the greatest returns on the capital invested when the income per kilowatt is nearly at a minimum. I believe our business to-day might be considered as of a retail nature compared with what it will be a few years hence. I see no reason why central-station companies should not furnish every bit of power used in any town, regardless of size of installation. One power house can be run more economically and with less aggregate capacity than several, and we must content ourselves with a smaller margin of profit per kilowatt, our future profit being represented by a greater degree of economy resulting from central-station operation versus isolated-station operation. One central station with which I am acquainted supplies eleven-fourteenths of all the power used in the town in which it is situated. The officers of that company are laboring with the other three-fourteenths, with strong prospects of acquiring the greater portion of it. Another central station with which I am acquainted did not make any appreciable gain in output for ten years, although they had a large increase in connected load and a slight increase in earnings. The whole condition resulted from the rates of charging in vogue. Their rates were so high, and so inequitable to users of light for long hours, that each year they were losing a portion of their connected capacity by the installation of isolated plants; but the natural growth of their town and business was giving them an increase in connected capacity of nearly three times that lost by isolated lighting, although from the standpoint of consumption their three new connected lamps did no more than compensate for the one lamp lost by isolated lighting. The investment for this station had gradually crept up until it represented an investment of $16 per lamp connected. Their connected load was 630 16-cp lamps, or their equivalent, per 1000 inhabitants. During the past year they have inaugurated a different policy, and their connected load has been materially increased without a corresponding increase in capital investment, and their investment now represents $12 per lamp wired up, and they have 917 lamps per 1000 inhabitants. I predict that they will have in another year 1500 lamps wired up per 1000 inhabitants, which will represent an investment charge of $8 per lamp wired up. Previously they were compelled to make $1.60 per lamp profit, over and above operating expenses, in order to take care of interest and depreciation. Now, if they brought their investment down to $8 per lamp wired up, they would only be required to make 80 cents above operating expenses to cover interest and depreciation.

Line, meter and transformer efficiency have often been so low in alternating-current stations that the stations were paid for but from 35 per cent to 65 per cent of the current sent out, and even then the cost of lost current in alternating stations was not as great as the additional interest charge in direct-current stations. Core loss in transformers and interest can be considered as charges of an identical nature. Assume that you are using individual transformers for each house, and are installing transformer capacity equal to 100 per cent of your connected load. We will assume that with a transformer installation of this magnitude, your iron loss is two per cent of its rated capacity. Now, two per cent does not look high, but it must not be forgotten that your two per cent is two-per-cent loss of current at full load, and 100-per-cent loss of current at no load. With a two-per-cent transformer loss, your aggregate loss is approximately 10 kw-hours per lamp per year. Your average sales per lamp per year in the average western station, covering both the residence and business districts, will be in the neighborhood of 18 to 20 kw-hours.

This average will represent lamps using from less than one kw-hour per lamp per year to 400 kw-hours per lamp per year. With an installation that averages one kw-hour per lamp per year, you must send from the station 10 kw-hours for loss in the transformer and one kw-hour to be sold. If you are selling current at 20 cents per kw-hour, you are getting for the one kw-hour sold 20 cents, but for the 11 kw-hours sent from the station, you are getting but 1.8 cents per kw-hour. As you increase your sales per lamp per year, assuming that your selling price remains constant, your income per kw-hour generated increases very rapidly. It is simply absurd to expect ever to develop the central-station business properly as long as charges are made only on the basis of current consumed; and what I have stated about the transformer loss is true also of the investment expenses that would be encountered if a direct-current station were used. If we must spend a dollar for interest, or spend a dollar for current to be lost in a transformer, we are no better off in one case than in the other. Personally, I believe I should prefer to spend a dollar for core loss in transformers, as we have better opportunities for reducing this expense than for reducing an interest expense. If every small consumer were made to pay all the costs that he occasions, we could sell current at a much lower average rate. At a much lower rate we can considerably increase our sales and can probably keep up the development of our market by reductions in the selling price without impairing the percentage return on the money invested. As we reduce the price of current we may expect a lavish use of it for sign and decorative lighting. We may also expect a great and rapid advance in the standard of illumination, which is already constantly increasing.

### OVERHEAD AND UNDERGROUND CONSTRUCTION

The question of forcing the central stations under ground is being agitated all over the country, and I feel that we are largely responsible for the dislike the public have for pole lines. It is possible to have overhead work that is neat and unobtrusive, and yet almost every central station in the country has unsightly, unpainted poles, with an irregular network of badly strung conductors, representing three or four times the number of wires needed for conduction of current. In the event of a feeder wire becoming too small, it has become the custom to string other feeders in parallel. The multiplicity of wires has hampered the fire departments and has become an eyesore to the public. It is simply impossible to go to underground construction except in districts of congested population, and while a great deal of harm has already been done by our bad overhead construction, it can be rendered less offensive and the agitation be quieted in a measure by a reformation of our methods. I recommend the purchase of only long, straight cedar poles, and that they be painted with such a color as will best harmonize with their surroundings. For instance, in the residence district, where there are many trees, we paint all of our poles green, in spite of the fact that the city ordinances in many towns demand that poles shall be painted with white and black paint only. It is also advantageous to use the minimum number of conductors, for as you install additional poles or conductors their objectionableness seems to increase in geometrical ratio.

We must give underground construction more consideration than heretofore. We had hoped at this meeting to have a text paper on this subject, but were unable to obtain assistance. What we want is a paper so complete and detailed that it will enable any central station man who is forced to put his wires under ground to undertake the work simply by the guidance of this paper; and, with the consent of your executive committee, I recommend that we make this a feature of our next convention, and with your further consent I will award a gold medal, properly inscribed, to the contributor offering us the most complete and comprehensive paper on underground construction, for either alternating or direct-current plants, or a combination of both; the selection of the best paper to be made by a suitable committee to be appointed by the incoming president.

### ADVANTAGEOUS WORK THAT MIGHT BE DONE BY THIS ASSOCIATION

I have been in the gas business for nearly 20 years and have been a member of various gas associations for a portion of that time. The gas business and central-station business are quite similar, and many years ago I conceived the idea that competitive conditions were of such a nature that it could not help but bring about consolidations of these interests. My belief is not yet fully realized; but whether actual consolidations do or do not take place, there is much to be gained by watching the methods of gas managers and gas associations, as they might also gain by watching our business and association methods. The recommendations that follow are largely influenced by my experience with both gas and electric companies and associations. The gas associations have more committees and the committees do more work. They not only attempt to cover engineering work, but also attempt to render every class of assistance to managers of companies. There is no school in which gas engineering is taught, so the gas fraternity has established a school of correspondence for the instruction of gas companies' employees. No less than three of the gas associations have what is called a Wrinkle Department. One man is appointed editor, and it is his duty to look up and report on novel appliances used in and about a gas works, or for trenching, laying pipes or services, and, in fact, any homemade contrivance useful to gas men generally. These wrinkle departments have created much interest at the meetings, and some points of great value have been brought out in this way. The Ohio Gas Light Association has an Advertising Department the editor of which is expected to keep us posted on all novel and attractive forms of advertising. This department has also proved of great interest to the gas fraternity. The dog advertisement which some of you may have encountered in the past few weeks, was contributed to the Ohio Association in March of this year, and has already been tried by numerous gas companies all over the country with excellent results. I think we should divide our work up into a number of departments and appoint an editor for each. I suggest that we have a Wrinkle Department, an Advertising Department, a Department of Decorative Lighting, a Department of Sign Lighting, and a Department for Office Methods and Accounting. I recommend that but one man be put in charge of each department as editor. I further recommend that our old committees be stirred up to greater activity, and if necessary that they be so arranged as to do active work. It is to be regretted that the committee on steam results has ceased to report. I recommend that a committee of one be appointed on lost and unaccounted-for current, and that a committee of one be appointed on thefts of current, whose duty it shall be to report on legal measures taken to prevent theft, and the novel means used to defraud electrical companies, so that others may be cautioned against fraud in the same manner. The editor on accounting and office methods can render much valuable assistance to all of us by reporting labor-saving office machinery brought out, the most desirable forms of consumers' contracts, and other necessary credit forms used in connection with our business, and the methods of collecting used by the various electric companies, which now differ very materially. It is customary for the smaller electric companies to read their meters once a month, and collect their bills once a month, but some of the larger electrical companies read all through the month and collect bills all through the month. I have never tried the latter scheme, but feel greatly inclined to do so; and I assume that if this question has agitated the mind of one central station, it may be agitating the minds of several others, and one investigation may suffice for all. The recommendation of the appointment of an editor for these departments is not intended to interfere in any way with the work of the committee on uniform classification.

I think we should extend an invitation each year to the professors of electrical engineering in all the colleges throughout the country, and address a letter to the faculties of the universities, calling their attention to the fact that by having the professors of electrical engineering attend our conventions they can keep in closer touch with central-station work, and be able to conduct more intelligently the course of studies for those students who expect to take up central-station work. Each year I have occasion to employ a number of young college graduates. They come to me sadly lacking in certain respects, particularly in their lack of knowledge of the laws of heat and thermodynamics, or else they are unable to apply whatever they know regarding this subject. They also seem to be incapable of thinking of expenses as anything but operating expenses, without regard to fixed expenses, such as interest, taxes, etc., and even if they do take these fixed expenses into their calculations they do not seem to comprehend how large an item of expense they may be, on a unit basis, if a plant can only be operated for a small portion of the time, while these expenses go on constantly 24 hours per day and 365 days in the year. It would also be greatly desirable if they could have some knowledge of accounting, but I do not know that it is practicable to give them a proper insight into this branch of our business during their college course.

I wish to acknowledge the assistance rendered me by T. Commerford Martin and W. D. Weaver in association matters, and to commend them for their interest in our association's progress. Mr. Cahoon has done very much in the association's behalf, and Miss Billings has worked nights, days, and Sundays, for the success of this meeting. Her loyalty and industry go beyond that warranted by her salary, and if this convention proves more interesting than former ones, I hope you will show your appreciation by giving Miss Billings a hearty vote of thanks.

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MR. NICHOLLS: I understand that the next order of business is to resolve ourselves into an executive session?

THE PRESIDENT: Yes, sir.

MR. NICHOLLS: Before we do that I desire to offer a resolution. I have listened, Mr. President, with a great deal of pleasure to the very able address that you have read. Some of the suggestions are of a most practical nature, and I would move that a committee be appointed by the chairman to take into consideration, on behalf of the association, the questions that have been put forward by you in your presidential address.

THE PRESIDENT: Would it not be better for that committee to be appointed by the secretary? I believe that is customary.

MR. NICHOLLS: By the secretary or by the chairman, so long as the committee is appointed. We should not disperse without taking action to make sure that the recommendations in the address are turned to some practical advantage on behalf of the association. I am willing that my motion should be so amended as to leave the appointment of the committee with the secretary.

(The motion was put and carried.)

THE SECRETARY: I will announce the committee later.

THE PRESIDENT: The Bullock Electric Manufacturing Company has invited us to visit its plant on Wednesday afternoon, at four o'clock; what action will you take in regard to the invitation?

MR. ARTHUR WILLIAMS: I move that we accept with thanks the invitation of the Bullock company for to-morrow afternoon.

(The motion was carried.)

THE SECRETARY: I will announce the committee on the president's address: Mr. J. H. Perkins, Youngstown, Ohio; Mr. R. S. Kelsch, Montreal, Canada, and Mr. C. E. Hewitt, Elkhart, Indiana.

THE PRESIDENT: If there is no further business, we will resolve ourselves into an executive session, and I will appoint Mr. Gallagher as sergeant-at-arms.

The meeting then adjourned to executive session.

# EXECUTIVE SESSION

PRESIDENT DOHERTY: Before we go to more important business, I will call for the report of the committee on amendments to the constitution. There was a committee appointed three years ago to amend our constitution, and the especial amendment desired was a change in the dues. Is Mr. Insull here? I do not think he is. I understand he is the chairman of the committee.

MR. FERGUSON: I am not certain whether Mr. Insull will be here or not.

PRESIDENT DOHERTY: Do you know whether he has a report to present?

MR. FERGUSON: I do not know anything about it.

PRESIDENT DOHERTY: This matter was taken up three years ago. I do not think Mr. Insull was able to get a meeting of the committee. I am on the committee, I think. I want to suggest, and you can do as you like about it, that after January 1st, 1903, the membership dues and annual dues be based partially on population. I am in favor of an initiation fee of $100, and annual dues of $10 for each member, plus 50 cents for each 1,000 inhabitants, with a maximum rate of $200 per annum. The dues will be made up by first making a charge of $10 for each member—believing in getting a certain minimum out of each member to cover the cost of proceedings, etc.; then we will collect 50 cents per thousand of population; but the maximum rate shall not exceed $200. If two or more companies from the same town are members of the association, the per-capita charge shall be divided equally among them unless they make some other arrangement mutually satisfactory to themselves. All companies not now in the association can join the association before January next at our regular rates, and in that way they will avoid the payment of the initiation fee. I offer that now as a suggestion. As we now stand we make a charge of $25 to everybody and there is no initiation fee. If a member feels like dropping out for a year he does so. The fact that we have no initiation fee renders it hard to keep our membership in line. This plan will give us about $2,200 more revenue than we now have, and it will enable us to go out and get at least 200 more small central stations that do not feel like paying $25 a year but would feel able to pay $12 or $20, as their fees would then be. Do you wish to discuss the subject, or to do anything about it at all? Will Vice-President Ferguson kindly take the chair?

(Vice-President Ferguson took the chair.)

MR. DOHERTY: Mr. Chairman, I recommend that this proposed change in dues be adopted and made effective January 1, 1903. I do this simply to bring out discussion. We have many members who have paid to that date. This gives us an opportunity to go out and get 200 small central stations as members of this association before January 1st, with proper work.

MR. JAMES I. AYER: I second the motion.

(The written statement of the proposed plan of new dues was again read by request.)

MR. GEORGE E. HAY (Springfield, Ill.): How will that apply practically? Supposing a city of 25,000 or 30,000 inhabitants should have one or more plants as is the case in Illinois in many towns; would each one of these plants be taxed that amount—would that be the ratio for each one, or for all of them?

CHAIRMAN FERGUSON: Mr. Doherty's idea is that the charge shall be divided mutually between all the companies proportionally.

MR. DOHERTY: Each one will be charged $10, and if there are three companies in a town of 30,000, each company would be charged for one-third of that number, or 10,000, in addition to the $10 which all companies pay alike.

MR. DECAMP: Does that mean that each one will pay the initial charge of $10 and the balance be divided up among the three companies as they see fit?

MR. DOHERTY: Yes, the balance to be divided equally, unless they see fit to adopt some other arrangement.

MR. DECAMP: In a city of 100,000 people, as I understand it, if there were two companies that were members of the association, each company would pay $10; that is the guarantee, as you might say, and what it really resolves itself into is that this association wants $10 plus 50 cents per 1,000 of population, if I interpret the matter correctly?

MR. F. A. BRYAN (South Bend, Ind.): Does that mean 50 cents for every 1,000 of population, or 50 cents for every thousand supplied with current?

CHAIRMAN FERGUSON: Fifty cents per 1,000 of population in the city. If the population in the city is 500,000, the maximum would be $200. Suppose it were 100,000, the amount additional would be $50 for the city, and the additional $50 would be divided among the companies from that city.

MR. BRYAN: Has the committee considered the advisability of charging for dues on the basis of output rather than the population of the city? There are some cities where the output is not so great as it should be.

Mr. Doherty: I would answer by saying that if a man does not realize the output he should, he should not blame the association for it.

Mr. P. G. Gossler: There are some companies that are very much smaller than others supplying light and power to the same city.

Mr. Doherty: You cannot divide it in any other way except this. If two companies are in competition in the same city, they can divide the dues in any way they want to. They would be likely, in most cases, to divide it equally. I see no other way of making this charge except on the basis of the population of the city, the last United States Census Report to govern.

Mr. Bryan: Do I understand that the manager of a plant located in a town of 3,000 inhabitants will have to pay an initiation fee of $100 in addition to the yearly dues, which latter are based on the basis of 50 cents per thousand of population?

Chairman Ferguson: That is the arrangement—$100 initiation fee, then $10 per year, plus $1.50 per year on the basis of population, in the case of a town with 30,000 population.

Mr. Bryan: I ask if you have considered that nine-tenths of the electric-light plants in this country are in towns of 2,500 to 4,000, and would not that rate of $100 be prohibitive?

Chairman Ferguson: They have a chance to come in before January 1st, without paying the initiation fee, if they want to.

Mr. Bryan: If that is the idea, to work up this territory and try to get them in before the first of January under the present rate, it may be a good idea to pass such a resolution; but if you allow that scale of rates to stand, and the object Mr. Doherty has in view is not accomplished by the first of January, I think it will hurt us more than it will benefit us to adopt this schedule of charges. I believe that $100 fee for any plant in a town of 2,500 or 3,000 inhabitants, such as is true of nine-tenths of the plants, would be a prohibitive rate.

CHAIRMAN FERGUSON: I think the gentleman is right—that in small towns it would be a prohibitive rate; but Mr. Doherty's idea is to gather in everybody before the first of January, and not let down the bars after that time.

MR. BRYAN: The contention I made was this: If Mr. Doherty's object is not accomplished by the first day of January it will act as a hardship on our future membership more than it will benefit us between now and the first of January. If an initiation fee could be arrived at, based on the population, I think it would accomplish the same results.

CHAIRMAN FERGUSON: Has Mr. Doherty considered that point?

MR. DOHERTY: I think the point well taken, and I will suggest this—that we refer this matter to a committee and let them readjust it. For goodness sake, let us do something. If we do go wrong, what odds does it make? We can change this thing.

MR. L. R. WALLIS, Woburn, Mass.: Mr. Chairman, I would ask if Mr. Doherty has any recommendation to make in regard to the associate membership—and I should rather judge that he might have; if he has I think it might be easier to carry this change in regard to the active members if he would anticipate the matter a little and tell us what he proposes to do with the associate members. In other words, we are going to assess ourselves more and we should like to know what we are going to do with the other people.

Mr. Doherty: I believe that we tax our associate membership about all that they should be taxed. Associate members are not allowed to do anything except to pay $20 a year — that is about their only privilege. They can listen to the papers, etc., but have very little voice in the active control of the association. I am perfectly willing to do anything for them. Let us creep before we walk. My idea is to get something done with the active members first. It would be like selling current; if you put the rate too high you will have a beautiful rate, but you will not have any membership.

Chairman Ferguson: I ask Mr. DeCamp to talk on this subject just a moment. I think that in Philadelphia there are about 20 companies, and perhaps he can answer the question as to the effect on the general companies in regard to the distribution of these dues.

Mr. DeCamp: I want to ask you if you propose to put the original motion.

Chairman Ferguson: Will you kindly answer the gentleman in front of you with regard to the matter of the distribution of the dues among the large companies in one city?

Mr. DeCamp: In our case the dues would fall on one company. But one company would be a member of the association; and as a matter of fact that is all there is now in Philadelphia.

Chairman Ferguson: Suppose the conditions were as they were five years ago, with all the companies separated.

Mr. DeCamp: Five years ago there were sixteen companies that would have been looked upon as concerns that should be members of this association.

Mr. Nicholls: With regard to the suggestion of Mr. Doherty, I agree with him that something should be done and done quickly; but I cannot say that I am with him entirely in the proposition that he has submitted. I think we should deliberate a little longer; our committee should deliberate a little longer, and make a recommendation to the next executive session, which I presume will be held to-morrow. It is rather a peculiar thing to assess the active members $100 irrespective of the size of the municipality they represent, and I think the matter should have further and careful consideration.

MR. BRYAN: If in order, I would offer an amendment to that: That the present committee having the matter in hand be discharged, and a new committee consisting of five, to be appointed by the chair, take up the question and deliberate upon it, and present in executive session, before the convention adjourns, their recommendation as to what to do with that proposition.

CHAIRMAN FERGUSON: I think it would be hardly fair to appoint a new committee when there is one existing which has not made a report.

MR. BRYAN: As I understand it, that committee has been in existence three years and has not been able to make a report in that time; and I believe a new committee of five members, if it is appointed, will make a report in a few days, and it should be appointed.

CHAIRMAN FERGUSON: Mr. Doherty must be a member of the committee *ex-officio*, and should be acquainted with their deliberations. I think he should to be able to speak for the committee, and I do not think there is any necessity for appointing another committee on this subject unless the first committee appointed should make a report and be discharged. If Mr. Doherty represents that committee, we should accept what he says as its report.

Mr. Arthur Williams: I understand that the recent growth in the membership of the association has been very considerable. Has it been made evident to the association that any change in the present method regarding the dues of members is desirable? As I understand Mr. Doherty's report, it is a personal report and not a committee report; and I would submit an amendment to the motion now before us to the effect that the recommendations of Mr. Doherty be referred to the existing committee with the request that we have a report at the next executive session of this convention.

Mr. Ayer: As I understand it, the committee that has this subject in charge is composed of members of the association who are absent. There is no representative of that committee here, except Mr. Doherty, and we have his individual expression. The sense of the meeting seems to be, from the expressions we have heard, that it is desirable to refer this matter to a special committee, to be appointed at this session, which committee shall report during this meeting. If we refer the matter back to the present committee we can only ask Mr. Doherty to repeat his recommendation. He is the only member of the committee present and consequently there is no point in referring the matter back to that committee. I think it would be proper to take the matter out of the hands of the present committee and make Mr. Doherty a member of any new committee, and have the subject reported back to the next executive session.

Chairman Ferguson: I think you seconded the original motion, Mr. Ayer. Will you accept the amendment of Mr. Bryan, and have the matter referred to a committee of three members to take the place of the present committee and report at the next session?

MR. DECAMP: Is that on the report which has been made?

CHAIRMAN FERGUSON: To consider the report and make a new recommendation which will be acted upon by the association.

MR. DECAMP: I do not know whether it is in order, but what I have to say may be of some assistance to the new committee in arriving at a conclusion. On the whole, I am personally inclined to be in favor of the report, but judging from what the gentleman from South Bend has said there seems to be some objection to the plan. Would it be in order to make a motion which shall go along with the original one as an amendment to this?

CHAIRMAN FERGUSON: I would say, Mr. DeCamp, that this committee is only going to consider the subject and make a report, and any of the gentlemen who have objections to what has been offered here are at liberty to make their suggestions to the committee, and when the committee reports will be time to discuss the matter further.

(The motion was adopted.)

MR. DOHERTY: One of the rules of this association is that we shall never name any manufacturer in our discussions, nor ever name any particular apparatus that is only manufactured by one concern. That often works an injustice to the manufacturer, and works an injustice to the interest in our meetings. There are certain things we cannot talk about without calling them what they are. I think there is only one company now in position to turn out steam turbines. We have also had a flood of questions on the Nernst lamp, also manufactured by one concern only. We have a flood of questions on all of these things, and I think that this association is big enough to say that we will refer in conventions to anything we wish, and give our members the liberty to refer to any particular apparatus. If anyone should abuse that privilege we can take proper steps to prevent further abuses. Those doing so are open to censure in aggravated cases, or we can authorize a censorship over their remarks and they can be erased from the record. We are handicapping our usefulness by having a rule prohibiting the reference by name to articles manufactured by certain manufacturers. Our programme contains a number of questions referring to the Nernst lamp. It contains a number of questions referring to steam turbines. There are a number of questions asked about arc-lamp regulators, and there are a number of questions about meters; and in order really to give our members the information they ought to have, we should be at liberty to refer to these special pieces of apparatus freely.

Mr. Ayer: I want to say that these rules were made for the protection of the programme committee. Some men have tried in the past to secure an advertisement of their wares by introducing them before the association in written papers. This rule enables us to reject improper papers by referring to the rules regarding the prohibition of reference to articles of trade where it is found necessary. I do not think that any hardship has been worked upon the members of the association at any time because of that rule. If we have wanted to talk about certain apparatus we have done so. In such cases we ignore the rules, but they are useful when you want to use them.

Mr. Doherty: I take it that it is satisfactory to the association that we be at liberty to refer to any piece of apparatus where it is difficult to describe it properly without referring to its name, and if that is the sentiment of the house I offer a motion that all members shall feel free to refer to any piece of apparatus or any particular system involved in the use of certain apparatus, calling it by name.

Chairman Ferguson: The stenographer can be requested to refrain from taking notes if we do not want the matter reported.

Mr. Doherty: In the discussion on rates, which we brought up because everybody seemed to want to hear it discussed, Mr. Dow, of Detroit, refers to the Kapp and Hopkinson methods in such way that I think it would be desirable to have someone outline the Kapp and Hopkinson methods of charging. I am not familiar with these subjects.

(The subject of the Kapp method was assigned to Mr. W. S. Barstow, and the subject of the Hopkinson method was assigned to Mr. Arthur Williams, of New York.)

(President Doherty resumed the chair.)

The President: There is one thing of prime importance that I want to bring to the attention of this executive session. Our former secretary and treasurer was absent a big portion of last year in Alaska. He got back sometime during the winter but was called away again only last week, and he handed in his resignation, on last Wednesday, I believe. It was necessary for me to appoint a new secretary and treasurer before this meeting. I appointed Mr. James B. Cahoon as secretary and treasurer before this meeting, subject to the approval of this executive session. His appointment dates from last week.

Mr. Arthur Williams: I move that the appointment of Mr. James B. Cahoon as secretary and treasurer of this association be ratified by this executive session.

(The motion was carried.)

Mr. Nicholls: Since that question has come up, I do not think we should adjourn the session without placing on record the esteem and regard which this association has for the late secretary and treasurer, Mr. George F. Porter. I have been associated with him for more than ten years; and, until the last year when his other business interests prevented him from giving the time and attention to his duties that he has done in the past, I think he made a most efficient secretary in every way, and did a great deal in the up-building of the association; and I would move, and am sure there will be plenty to second the motion, that an address be presented to Mr. George F. Porter, our late secretary and treasurer, expressive of the regard of the association for him personally and their appreciation of the work he has done for the association in the past.

(Vice-President Ferguson in the chair.)

Mr. Doherty: I have much pleasure in seconding the motion made by Mr. Nicholls.

Chairman Ferguson: I am sure you will all agree with Mr. Nicholls in his remarks, and I will ask you to vote on the question.

The motion was unanimously carried and the following resolutions passed:

Whereas, The National Electric Light Association has learned that owing to imperative business reasons Mr. George F. Porter is compelled to tender his resignation as secretary, it is hereby

*Resolved*, That the association takes this opportunity at its annual convention, at Cincinnati, May, 1902, to express its deep sense of regret at this serious loss, and

*Resolved*, That the association desires to put on record its appreciation of the loyal and intelligent service rendered by Mr. Porter for ten years, and of the excellent results that have attended his efforts to promote the welfare of the association and the interests of those engaged in the electric-lighting field, and

*Resolved*, That this expression of esteem and good will be entered upon the minutes of this association and be presented to Mr. Porter in engrossed form.

## SECOND SESSION

The meeting was called to order by President Doherty at ten minutes after two.

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THE PRESIDENT: At the executive session this morning a motion was carried that there be a committee appointed on the revision of the constitution and by-laws in regard to dues. Chairman Ferguson has appointed Messrs. C. L. Edgar, of Boston, Chairman; Frederic Nicholls, of Toronto, and Charles E. Hay, of Springfield, Illinois, as the committee.

The programme for this afternoon begins with the paper by Mr. W. E. Moore, of Augusta, Georgia, on the subject, "Does It Pay to Treat Poles with Creosote, Oil, or Other Compounds?"

Mr. Moore then read his paper, as follows:

# DOES IT PAY TO CRESOTE WOODEN POLES FOR ELECTRIC LINE WORK

An electric lighting system may be divided into three principal parts, viz.: The generating station, the distributing lines, and the house wiring, with lamps, motors, meters, etc.

At the various conventions of this association numerous papers have been read tending to show how the cost of production and reliability of service may be increased by various improvements in the generating plant. We have also had numerous papers on arc lamps, their light-distribution curves, power factors, and their different systems of operation; on incandescent lamps with their candle-hour and efficiency curves, and on meters, which now determine almost entirely the revenue of the company. There has, however, been very little said on the distributing system and how to reduce the expense of maintaining the lines, notwithstanding that in the operating expense of most companies approximately one-third of the income goes toward the distributing expense, of which the maintenance of lines constitutes quite a large item. The principal cause of the depreciation in the lines is due to the decay of poles, for as yet but few lighting companies have begun the use of iron or creosoted poles, though iron poles are extensively used for street-railway purposes.

The wooden pole is usually of cedar, sawed-heart pine, cypress, juniper or red wood, and is generally used on account of its low first cost and the comparative safety with which workmen may handle the live wires when standing on the cross-arms, as wood is a fair insulator when dry.

Red-cedar and white-cedar poles, while they have a comparatively long life, have now become so scarce that it is extremely difficult to secure them in sufficient numbers of suitable sizes for electric-light lines at any price in the eastern or southern market, though there is yet a considerable supply of white cedar to be found in the northwest. Cedar, when of good quality, has the capacity of resisting .the attacks of insects and fungous growths to a greater extent than any other wood used in this country for poles. This statement applies only to the heart of the stick, and more especially to red cedar; the sap or white portion quickly rots away at a point near the ground.

In the southern and eastern cities cypress is largely used, and in its natural state has a life of from five to six years in the southern portion of the United States, and a somewhat longer life in the North.

Heart-sawed pine poles have a somewhat longer life than cypress, ranging from eight to nine years; but sap pine, though readily secured in sticks of suitable size and of the necessary length, is never used, on account of its rapid decay. It lasts scarcely more than three years when used without being treated with some preservative compound.

It is much more expensive to renew decayed poles than is the original cost of setting them, due to the fact that they do not all decay at one time and it is therefore necessary to reset them piecemeal; and it is also necessary to take care of the wires while they are being reset, which is often quite expensive in case there are a large number of wires attached to one pole, especially if it be a junction pole.

For these reasons the Augusta (Ga.) Railway and Electric Company began some nine years ago to study the problem of treating poles by preservative compounds to increase their life. Our first experiment consisted of charring the butts of the poles, up to and about one foot above the earth line, and then coating them with coal-tar paint; but this was found to be of little service. We then tried painting the poles with various brands of preservative compounds sold under different trade names. These also were found to be of little or no benefit. In the meantime our poles, which were almost entirely of cypress, continued to rot out after an average life of about five to six years.

Some three years ago, after having investigated the results obtained both in this country and abroad from creosoting poles, we purchased and installed a creosoting plant capable of treating poles and cross-ties. This plant consists of a steel cylinder six feet in diameter by one hundred and two feet long, with heavy cast-iron heads, securely supported on hinges and arranged to be clamped against fibrous gaskets on the heads of the cylinder in a secure manner so as to resist a hydrostatic pressure of one hundred and fifty pounds per square inch. This cylinder has a narrow-gauge railway laid through it, with tracks continuing beyond the ends of cylinder. There is sufficient yard room at one end of the cylinder for storing untreated poles, and at the other for treated poles. The cylinder has a series of inch pipes laid from end to end and covering its bottom side between tracks. These pipes are arranged to be supplied with steam from an eighty-horse-power return tubular boiler, which is superheated, by means of pipe coils in a separate furnace, to a temperature of approximately four hundred to five hundred degrees. To the cylinder is also connected a fourteen-inch by twenty-four inch direct-acting vacuum pump, and, again, a fourteen by ten by eighteen-inch direct-acting oil-pressure pump.

The poles are loaded on to a train of iron cars which are then drawn through the cylinder by means of a wire rope attached to a hoisting engine. The cylinder doors are bolted up tightly, after which live steam is turned on the cylinder until a pressure of eighty pounds is reached, which is maintained while superheated steam is being circulated through the heating coils in the bottom of the cylinder. This steaming process is continued for a period of from four to six hours, depending upon the size and kind of timber that is being treated. The steam pressure is then drawn down and a vacuum is pumped on the cylinder containing the timber, which has been heated to a temperature approximately three hundred and fifty degrees. The effect of evacuating is to season the green timber by drawing the sap and air from its pores. This is facilitated by the steaming to which the timber has been subjected, which has had the effect of dissolving the sap and raising it to a temperature far above the boiling point, due to reduced pressure when the vacuum is applied. The sap in the pores of the wood is immediately volatilized upon the application of vacuum, which has the effect of making the extraction of both sap and air very rapid and complete. After a treatment in the vacuum lasting from two to six hours, during which time a quantity of sap is pumped from the cylinder through the vacuum pump, the valve connecting the creosoting cylinder with the oil-storage tanks, which are of thirty thousand gallons' capacity and located in a pit below the cylinder, is opened and the atmospheric pressure forces the creosote oil up into the cylinder until it is filled. After this the oil-pressure pump is started, drawing its supply from a tank which has a gauge attached, calibrated to gallons. When the pump has completely filled the cylinder, its operation is continued until the required number of gallons of creosote oil have been pumped into the cylinder to saturate the timber, the cubic contents of which have previously been figured, to a density of ten to twelve pounds per cubic foot. This ordinarily requires a pressure of sixty pounds of oil per square inch, applied for a period of time ranging from one-half to four hours, depending upon amount of oil per cubic foot, the size and kind of timber being treated. After the required number of pounds of oil have been injected into the timber, the oil is drawn from the cylinder into the storage tanks and the steam is left circulating through the superheating coils for about one hour for the purpose of somewhat decreasing the oil drippings from the timber, which would otherwise take place.

It is to be understood that steam is circulated through super-heating coils located in the bottom of the cylinder throughout the entire process, which ranges from sixteen to twenty-four hours. The doors of the cylinder are then opened and the cars with their load of treated timber are drawn through the cylinder to the unloading yard by means of the hoisting engine applied through a wire cable. Another train of cars, which is standing already loaded at the other end of the cylinder, is immediately drawn in and the process repeated.

The approximate cost of the average size (say thirty-four-foot by eight-inch top diameter) cypress pole in the South ranges from one dollar and seventy-five cents to two dollars and fifty cents each, and the cost of creosoting approximates twenty dollars per thousand feet board measure, or about twice the first cost of pole. While we have no time test showing the ultimate life of creosoted poles in actual service, we have every reason to believe that their life will be prolonged four to six times that of untreated timber. The Bell Telephone Company has used creosoted pine poles for upwards of ten years, and where the treating has been properly done they have yet to show the first signs of decay. Sir William Preece, of the British Telegraph Department, reports that creosoted poles have been in use in England for more than thirty years without showing any indications of decay. Since the cost of treating a pole averages only about twice its first cost, the economy of creosoted poles must be apparent to all.

The art of treating wood for its preservation is an old one, having been practiced in one form or another for many years. Among the various chemicals used are chloride of zinc, zinc and tannin, sulphate of copper, bichloride of mercury, wood-creosote oil and dead oil of coal tar. The latter is the most generally used chemical for wood preservation, and it is also more expensive than any other. The treatment of wood with creosote oil from coal tar has been far more successful and generally used than any other process and is usually specified by the United States Government.

Thus far we have found only one objection to creosoted poles, which is due to the tarry acids contained in the creosote oil, principally carbolic acid. The effect of these acids is to make the handling of the poles disagreeable, as they inflame the hands of those who handle them, and at the same time they lower the electrical resistivity of the timber to such an extent that linemen can no longer depend upon the poles to insulate them from the ground when handling 1,000-volt to 3,000-volt wires.

The principal preservative property of creosote oil appears to be due to its naphthalene, which is deposited in the pores of the wood, together with the antiseptic acids always found in dead oil of coal tar.

DISCUSSION

THE PRESIDENT: Are there any questions you wish to ask Mr. Moore regarding the subject of the paper?

MR. PRICE (New Bedford): I would ask if the creosoting of the pole increases its weight?

MR. PATTERSON (Waterville, Me.): I ask the writer of the paper if he thinks it necessary to apply pressure after having formed the vacuum in treating the pole?

MR. MANWARING (Philadelphia): I did not notice any mention made of using chestnut poles. How do they compare with the creosoted poles?

MR. WYANT (Derby, Conn.): I ask the relative values of the different kinds of poles after being creosoted?

DR. PERRINE: Mr. President and gentlemen: It strikes me that the Augusta company has tried a very valuable experiment—perhaps it is not right to say experiment—they have installed a very valuable process; but it seems to me that Mr. Moore has not given us a very full account of his secrets involved in this process, or else the work is carried on in a haphazard way. The United States Government has published, in connection with the question of the preservation of railroad ties, a large series of papers, going into this problem very thoroughly; and having occasion to look it up in connection with treating poles and cross-arms, I was aided a number of years ago by the engineer of the Southern Pacific Railroad Company, which is doing this extensively. The practice of the Southern Pacific company differs from the practice of

Mr. Moore in material respects. I think that the practice laid down by the Government in its work on railroad ties, and by Preece, who is referred to here, is different from Mr. Moore's. In the first place they object to temperatures as high as 353°, for two reasons. Cellulose begins to carbonize at temperatures of about 300°, and they prefer to keep the temperature below that which carbonizes the wood. In the second place they claim that the rapid exudation of the sap, due to the application of a vacuum, as well as these high temperatures, produce explosions that check the wood seriously. I believe the processes of the Bell Telephone Company are similar to Mr. Moore's, but they use a very much lower temperature. The process of the Southern Pacific Railroad Company is to fill the tank first with the dead oil of coal tar and then apply the vacuum at a moderate temperature, exhausting the sap and water from the wood very much more slowly. This process of exhausting the sap without the use of the dead oil of coal tar, or exhausting wood after the coal tar has been admitted to the tanks, does not seem to affect the result of the process very much, provided the process is not carried on too fast, and explosion does not occur and the wood is not checked. The Bell Telephone people assert that they get no checking with the wood they use, evaporating the wood dry, and the Southern Pacific people say that they do get it with the woods used on the Pacific coast, only getting freedom from the checking when they fill the tanks first with tar. Further, all the processes of which I know determine how much water is coming off and how much remains in the wood, by condensing the moisture as it comes away from the wood. The limit is set when the water comes off at a certain rate. In the Southern Pacific process they exhaust the wood until no more than a quarter of a gallon per thousand cubic feet comes off in one hour. The wood is then dry enough. They finally all agree that the effect of creosoting is, as Mr. Moore says, due to the use of naphthalene in stopping the pores of the wood and preventing any further water getting in; consequently, in all efficient creosoting, the framing of the poles, or otherwise cutting them, must be done before the poles are treated. The Southern Pacific Company had one case where a culvert was found to be rotted out in a form similar to an iron channel beam. In examining the history of the case they found that it was a creosoted stick sawn in two which had been used for the culvert, and where the creosote had been punctured the wood had rotted. Consequently they are careful to frame their poles before the creosoting is done, and if it is absolutely necessary to cut the wood after the creosoting is done they then tar it again with hot creosote. I note that Mr. Moore does not state anything regarding the specifications of his creosote. That is considered an important matter. The European practice has been to rely largely on the antiseptic creosote and other oils in the wood. Examinations of wood that has been down more than six months show that the antiseptics have evaporated and that the process is simply a process of seasoning, and stopping up the pores subsequently. It is therefore important to specify how much naphthalene per pound of dead oil is contained in the material purchased.

Another question is that of the insulation obtained with the creosote or dead oil of coal tar. With a large amount of creosote or carbolic acid, there is no question but that the insulation is temporarily reduced; but with a large amount of naphthalene and a small amount of creosote or carbolic acid, the insulation is not reduced; and these facts call for careful wording of the specification. The process seems to have proved to be entirely effective when the minor points are taken care of.

As regards quality and strength of the wood, the Bell Telephone Company maintain that one of the advantages of creosote is that they can efficiently use loblolly pine, or other cheap materials, for their cross-arms, provided they creosote them. They get as good endurance with the poor woods treated as with the good woods untreated. Furthermore, as regards the strength, both the companies of which I speak assert that they can use as high tensile strains with treated wood as with untreated wood, in spite of the fact that the treated wood shows in tests less strength than the untreated wood. The untreated wood shows greater strength when you install it, but after two or three years it loses strength, so calculations have to be made of the average strength of the wood during its life; and the strength of the treated wood is as great at its beginning as the average strength of the untreated wood during its period of life. Consequently, although the strength is reduced in our calculations, you can use as high unit stresses as with the untreated woods.

THE PRESIDENT: I have been asked to request you to give us the names of these government publications to which you have referred, by description or number, so that the members can secure them.

DR. PERRINE: I am unfortunate in not remembering the names of these publications, but they are issued by the Department of Agriculture, and one of them—the largest—I know is on the preservation of timber for railroad ties. The Department of Agriculture publishes a bulletin giving a list of all their publications. The list is not long, and it is quite easy to select from it the names of the publications you desire to consult. You can obtain this list by writing to the department, and can select from the list the publications that relate to the treating of timber. If anyone is particularly interested in them all, and will write me regarding them, I shall be glad to furnish a list of these publications or to correspond further with them on the subject under consideration.

THE PRESIDENT: What do you pay for your dead oil? A gentleman suggested to me that by treating the pole with lime after creosoting it, it will not be quite so apt to attack the skin of the hands of the men who handle the poles.

MR. MOORE: In regard to the weight of the poles, I will state that for our work we use 10 or 12 pounds of dead oil per cubic foot of timber. When the timber is saturated to that extent it will still float in water. For government work 19 to 20 pounds to the cubic foot is used. I have never made any test of the weight to see what weight is added to the pole. It will vary with different kinds of timber; sap pine will absorb more oil than hard pine or cypress. The question was asked if pressure is necessary after having the vacuum formed. It is essential if you want to saturate the timber to any extent. With dry wood or thin boards there will be no vacuum or pressure necessary. In regard to chestnut poles, we have found that they have a very long life; but in our country we can not get chestnut poles to any extent, and when we do get them they are so crooked that we are ashamed to see them on the streets.

Regarding the relative values of different woods for creosoting, we consider a sap-pine pole as good as cypress after treatment, except that it is not so strong.

Soft pine absorbs so much creosote that it gets somewhat brittle after treatment and will not bear the same strain as before. With a cypress pole we find the strength practically the same after treatment as before.

In regard to the specifications for creosote oil, we use domestic oil, which runs about 45 per cent naphthalene and costs us eight and a half cents per gallon. When timber is treated with 10 or 12 pounds of oil per cubic foot the creosote does not penetrate entirely to the core of the timber; but the sterilization is complete on account of the temperature to which the timber is subjected, and the outside surface of the wood is thoroughly protected. The holes are all bored and gains cut beforehand, so there is no opening left for the entrance of germs. If the pole has to be cut or bored after treatment, we apply hot creosote afterward. A gentleman has stated that by using the right kind of creosote the insulation of the timber would not be reduced below that of dry timber. We have never found any creosote oil that does not lower the insulation to such an extent as to make it very disagreeable to handle high-voltage wires on the pole. President Doherty's suggestion of treating the poles with lime water after creosoting would undoubtedly prove of some advantage; but we believe that these poles would still show leakage enough to hurt a man if he got hold of a live wire. I may say here that the publication referred to, which was issued by the Department of Agriculture, regarding the process of creosoting ties, is entitled "Metal Railroad Ties." This treatise gives a description of all the various processes for treating timber.

The President: We have an inquiry in our question box closely related to the subject now before us, but it is with reference to a less elaborate treatment than that recommended by Mr. Moore. The question is: "How may the butts of hard pine poles be best preserved?" I would suggest that perhaps good results might follow the use of a band of tar around the pole, extending two feet below and one foot above the ground. If the tar is green when you set the pole, dust it with lime and it will not come off on anyone's clothes. This treatment in a measure prevents rotting at the base line. The idea is not to tar the whole butt of the pole, but to leave the bottom open for the free movement of the sap out of the bottom.

THE PRESIDENT: The next order of business is the papers on the incandescent lamp. Mr. Bailey has requested that his paper be postponed until to-morrow; we will therefore take up the papers on lamp efficiencies.

# WHAT EFFICIENCY LAMP SHOULD BE USED, AND HOW MAY THIS EFFICIENCY BE DETERMINED FOR ANY PARTICULAR STATION

NEW YORK, March 7, 1902.

MR. S. E. DOANE, Marlborough, Mass.

DEAR SIR: The National Electric Light Association has departed somewhat from its usual programme methods, to the extent of substituting for papers written discussions of certain subjects considered of great importance to the various central station managers. One of the subjects selected is "What Efficiency Lamp Should be Used, and How May this Efficiency be Determined for Any Particular Station?"

My own views are that the efficiency of the lamp, assuming that we are using as a standard a lamp of sixteen candle power, should be placed at that point where cost to the central station for the supply of current just balances the cost of lamp renewals; and that when this point has been determined for a sixteen-candle-power lamp, then all the other-sized lamps should have an efficiency that would bring the cost of lamp renewals to the same point per kilowatt hour consumed. In other words, when lamp renewals for any given efficiency lamp cost any more than it would cost the central station to supply additional current to yield the same amount of light from a lamp of lower efficiency, they should adopt this lower-efficiency lamp.

I do not think our rate of charges to the consumer should be considered at all except that we can afford to make a reduction in rate for the lower-efficiency lamps used. The only cost I see to the electric company in using lower-efficiency lamps would be boiler fuel and boiler-room labor, and costs incidental to a larger equipment. Boilers, engines, dynamos, conductors and transformers would have to be increased, and this would add additional costs for interest, taxes and depreciation on this increased investment.

Please give us your views on this subject at the earliest possible date, sending them to Mr. George F. Porter, secretary, 136 Liberty street, New York.

Yours very truly,

HENRY L. DOHERTY, President.

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MARLBOROUGH, MASS., April 2, 1902.

MR. HENRY L. DOHERTY,
President National Electric Light Association.

DEAR SIR: In accordance with your letter of the eleventh ultimo, I have tried to find some points of difference, but I can't see that we can differ at all. You have put the whole matter so clearly that all I shall attempt to do will be to point out some facts that may or may not be in your possession. If not, they will be of use to you.

Of course, as you say, the cost of a lamp to a station includes the cost of the power it consumes during its life.

I was told not long ago by a station manager that he preferred to use 3.5-watt lamps as his station was loaded now; he could not get any more equipment, as considerable outlay would be necessary to extend the station for it and the money for this could not be conveniently procured.

He must also hold up his income, and he was in business to sell current. He was selling all he made, and any pressure that would be brought to bear to reduce customers' rates would be in the nature of a demand to sell current as cheaply as some neighboring town, without regard to whether the monthly bills were lower or otherwise. He said he was prepared to burn 3.1-watt lamps as soon as his increasing load—increase that he could not avoid—overloaded his apparatus dangerously. He said he would increase his expenses by using 3.1-watt lamps, and would not increase his income.

That was the other view of the matter. This view is what I used to combat.

You evidently believe it pays to furnish a man with his light at as low a figure as is consistent with a good business profit, and to do a large business. So do I.

Any central station can say: "If I burn a lamp in this socket continuously for a year it will cost me so much for energy and so much for renewals," including in the first all charges for all purposes except the actual cost of the lamp, cost of freight on them, photometer work, etc., etc., and including in the latter the cost of the lamp, etc., etc.

By making three columns and heading one 3.1-watts per candle, the second 3.5-watts per candle, and the third four-watts per candle, it would not take long to find out which was cheapest.

To facilitate such an operation, here are some figures:

100 to 130 Volts

| Candles | Life to 30 per cent initial candles | | | Ultimate Life | | |
|---|---|---|---|---|---|---|
| | 3.1-wpc | 3.5-wpc | 4.0-wpc | 3.1-wpc | 3.5-wpc | 4.0-wpc |
| 8 | ... | 175 | 400 | ... | 210 | 500 |
| 10 | ... | 185 | 425 | ... | 230 | 550 |
| 12½ | 95 | 195 | 380 | 120 | 250 | 450 |
| 16 | 100 | 175 | 340 | 130 | 210 | 375 |
| 19 | 90 | 150 | 340 | 120 | 165 | 340 |
| 24 | 80 | 150 | 320 | 110 | 225 | 340 |
| 32 | 80 | 140 | 300 | 100 | 225 | 340 |
| 50 | 70 | 120 | 260 | 100 | 170 | ... |

These percentages in round figures are approximately accurate, and will hold under any reasonable conditions of lamp quality and voltage variation so long as the 3.1-watt lamp is taken as a basis.

I say this because any maker that can make a 3.1-watt lamp that will meet his guarantees, will have no trouble with those of 3.5 watts and four watts.

Yours very truly,

S. E. Doane.

## L. G. VAN NESS

For the purpose of these calculations I will assume: That sixteen-candle-power lamps only are to be considered; that the life of lamps on perfect regulation is, for 3.1-watt lamp 420 hours, for 3.5-watt lamp 750 hours, and for 4-watt lamp 1,500 hours; that lamps will be changed periodically by the company, and these changes made often enough so that lamps burned until midnight will not exceed their normal life.

The most desirable efficiency of lamps will then be determined by

(1) The average regulation of the circuits.
(2) The generating costs that are strictly proportional to output.
(3) Investment per kilowatt capacity of the station.
(4) The average consumption per lamp per year.
(5) The charge per kilowatt hour to consumer.

### AVERAGE REGULATION OF THE CIRCUITS

I have taken as the first consideration the average regulation, as that determines the life of the lamp; therefore, the cost of lamps per kilowatt hour sold. With perfect regulation, the life of lamps is fairly well determined; but as none of us can claim perfect regulation, we are obliged to assume the degree of perfection, and accept the claims of the manufacturers as to the life of lamps under variable voltage. The manufacturers nearly all agree that an excess voltage of one per cent will reduce the life of lamps to about eighty-eight per cent of the normal. Beyond this point there is a wide difference of opinion, and I know of no independent tests to guide us in assuming the life of lamps at excess voltage. I will assume, therefore, that if our regulation is so bad as to be equivalent to an excess voltage of over one per cent, we should devote our attention to the improvement of the regulation, and postpone the question of lamp renewals temporarily.

We have very few data at hand from which to determine the average cost of testing and renewing lamps, but from the information available, I should estimate it at one and one-half cents per lamp renewed. With lamps at sixteen cents each, our costs per kilowatt hour for lamps and for renewing would be as follows, for perfectly regulated circuits:

| Life | Period of Renewal | Cost of Lamps per Kw. Hour | Cost of Renewing per Kw. Hour | Total Cost per Kw. Hour |
|---|---|---|---|---|
| 3.1-watt 420 hours | 70 days | .76 | .071 | .831 |
| 3.5- " 750 " | 125 " | .38 | .036 | .416 |
| 4 " 1500 " | 250 " | .164 | .016 | .18 |

With regulation equivalent to an excess of voltage of one per cent, they become:

| Life | Period of Renewal | Cost of Lamps per Kw. Hour | Cost of Renewing per Kw. Hour | Total Cost per Kw. Hour |
|---|---|---|---|---|
| 3.1-watt 370 hours | 61 days | .366 | .081 | .947 |
| 3.5- " 660 " | 110 " | .433 | .04 | .473 |
| 4 " 1320 " | 220 " | .189 | .018 | .207 |

## GENERATING COSTS THAT ARE STRICTLY PROPORTIONAL TO OUTPUT

These costs affect the lamp efficiency, inasmuch as they are the only operating costs that are increased by substituting low-efficiency lamps for those of higher efficiency. The question is to determine the costs that are strictly proportional to output.

Boiler Fuel is practically the only item that varies with the output.

Boiler-room Labor would vary nearly in proportion to the output if we considered large stations only;

with smaller stations the item changes but slightly with changes of load.

Engine and Dynamo Labor is affected slightly in large stations and practically not at all in smaller ones.

Dynamo and Engine Repairs is affected to some extent, but the items are not large compared with the total expense. The remaining items may be considered constant with the small changes we should make by changing the efficiency of lamps. We can not be greatly in error if we assume that the fixed portion of boiler-room labor is equivalent to the variable portion of the other expense. We will therefore consider boiler fuel and boiler-room labor as strictly proportional to output, with which we will calculate the cost of extra current for lower-efficiency lamps.

## INVESTMENT PER KILOWATT CAPACITY

If we substitute lamps of lower-efficiency for lamps in service, we must provide additional capacity for the additional demand; then we must charge against the low-efficiency lamps the cost incurred by the increased investment.

Taxes, interest and depreciation are all the costs that would be affected. Calculating these at twelve per cent on, say, $125 per kilowatt as investment, gives us fifteen dollars per year fixed charge per kilowatt capacity of increase.

If we substitute 3.5-watt lamps for 3.1-watt lamps, we must increase our equipment 12.9 per cent, or for each 7.7 kilowatt, equivalent to 154 lamps, we add one-kilowatt capacity; thus our increased fixed charge would be distributed among the 154 lamps. This is equivalent to nine and three-fourths cents per lamp per year. Substituting four-watt for 3.1-watt lamps, we must increase the equipment twenty-nine per cent; the charge will be distributed among sixty-nine lamps and the fixed cost per lamp per year is twenty-one and three-fourths cents.

Substituting four-watt for 3.5-watt lamps, the equivalent is increased 14.3 per cent and the increased cost is divided among 140 lamps, or the cost per lamp per year is about ten and three-fourths cents.

### AVERAGE CONSUMPTION PER LAMP PER YEAR

The average consumption must be considered, as the last item is a fixed cost per lamp per year. To reduce this to a cost per kilowatt hour consumed, we must determine how much the lamps are to be burned. The fixed cost per lamp, as calculated above, reduced to cents per kilowatt hour for various kilowatt hours' consumption per lamp per year, is as follows:

| Consumption per lamp per year kilowatt hours............ | 20 | 40 | 80 |
|---|---|---|---|
| Fixed cost to change from 3.1 to 3.5 cents per kilowatt hour. | $ .48 | .24 | .12 |
| Fixed cost to change from 3.5 to 4 cents per kilowatt hour. | .54 | .27 | .13 |
| Fixed cost to change from 3.1 to 4 cents per kilowatt hour. | 1.08 | .54 | .27 |

It will be seen by inspection that we can much better afford to increase our investment for liberal users of light than we can for consumers using their lamps but a small portion of the time.

### CHARGE PER KILOWATT HOUR TO CONSUMER

This consideration is more in the nature of a limit to the possibilities. We can not with impunity change from 3.1 to 3.5-watt lamps if our consumers are paying for current on a kilowatt-hour basis, as it will raise their bills approximately 12.9 per cent. This we know will make trouble for all, from the manager to the meter reader. We may change from 3.5 to 3.1-watt lamps, but the effect on the consumer avails us little. We may advertise the fact thoroughly that we have reduced the bills ten per cent and give the same amount of light, yet we know from experience that not more than ninety-nine per cent of our consumers will take our word for it and give us credit for a ten-per-cent reduction. We should get much more credit if we changed from a 3.1 to a 3.5-watt lamp and gave a reduction of ten per cent on the bill, although by doing this we really raised their bills about three per cent.

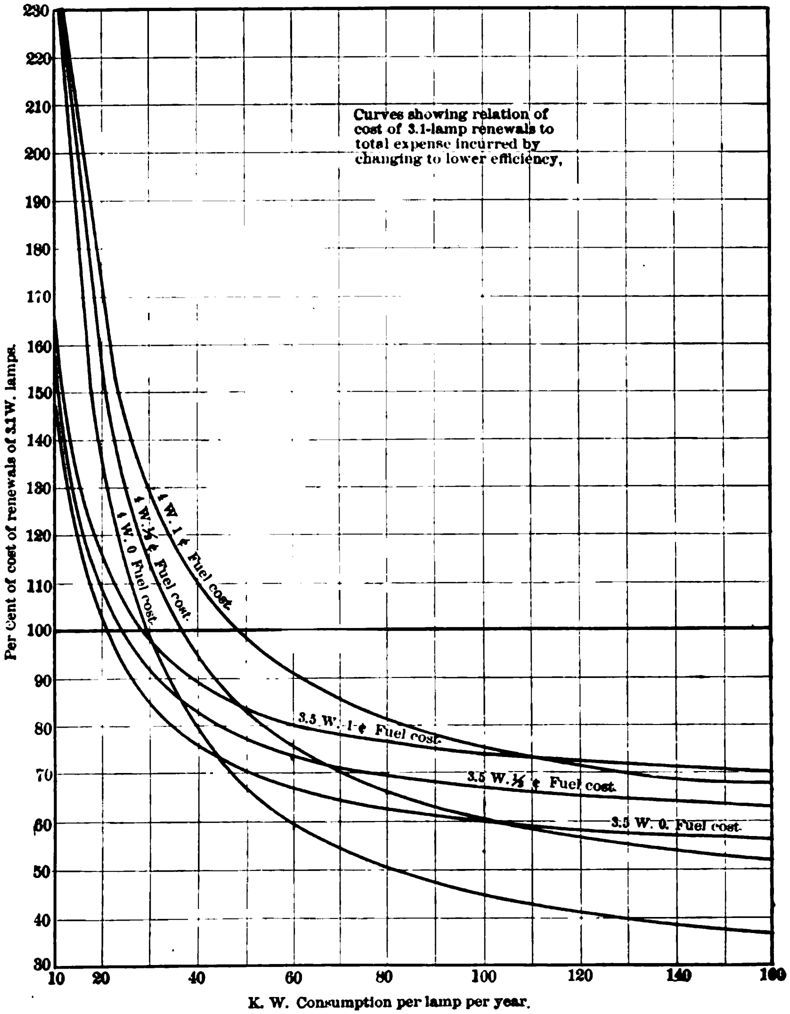
It is true that we might take on more business by using a more efficient lamp, but we ought to derive considerable benefit to repay us for doing more business for a less net profit.

If we have a combination flat and kilowatt-hour rate, we may change the lamps without materially affecting consumers' bills, provided the kilowatt-hour rate is not too great a portion of the total charge. The ideal combination rate would give us about thirty-three per cent of our income on the kilowatt-hour charge, and an increase of 12.9 on this would mean an increase in the bills of about four per cent, which would scarcely be noticeable. It is evident that we should consider the charge to the consumer for each specific case, but for the sake of simplicity we will eliminate it by assuming that we will give a discount that will exactly balance the increase in the bills that would result if we substituted a lower-efficiency lamp for those in service. Then we may collect our figures for comparison in the following table :

| Lamp Eff. | Cost of Lamps and Renewing | Increase of Fixed Cost on Basis of Consumption per Lamp per Year of | | | Cost of Extra Current at 1c. | Total Cost on Basis of Consumption per Lamp per Year of | | |
|---|---|---|---|---|---|---|---|---|
| | | 20-Kw. Hr. | 40-Kw. Hr. | 80-Kw. Hr. | | 20-Kw. Hr. | 40-Kw. Hr. | 80-Kw. Hr. |
| 3.1 | .947 | 00 | 00 | 00 | 00 | .947 | .947 | .947 |
| 3.5 | .473 | .48 | .24 | .12 | .129 | 1.082 | .842 | .722 |
| 4.0 | .207 | 1.08 | .54 | .27 | .29 | 1.577 | 1.037 | .767 |
| | | | | | Cost at ¾c. | | | |
| | | Same as above | | | 000 | .947 | .947 | .947 |
| | | | | | .086 | 1.059 | .809 | .689 |
| | | | | | .218 | 1.505 | .965 | .695 |
| | | | | | Cost at ½c. | | | |
| | | Same as above | | | 000 | .947 | .947 | .947 |
| | | | | | .064 | 1.017 | .777 | .657 |
| | | | | | .145 | 1.432 | .892 | .622 |
| | | | | | Extra Current Furnished by Water Power | | | |
| | | Same as above | | | 000 | .947 | .947 | .947 |
| | | | | | 000 | .958 | .713 | .593 |
| | | | | | 000 | 1.287 | .747 | .477 |

I have assumed that we have a regulation that is equivalent to one per cent excess voltage. For a better regulation the cost for lamps and renewals would be decreased, and for a poorer regulation increased.

We have thus far neglected to mention one important item. In the tables showing period of renewals we find that 3.1-watt lamps must be renewed every sixty or seventy days to prevent midnight consumers from burning their lamps beyond their useful lives. Some of these lamps will burn all night and reach their limit in thirty days. Now just what the period of renewal should be is a matter of conjecture with many of us, but it would scarcely be practicable to renew every thirty days; neither can we neglect these long-hour consumers, as we should be depriving our very best consumers of the benefits that the



CURVE ILLUSTRATING TABLE ON PRECEDING PAGE system was devised to give. It may be noted that the consumption per lamp per hour will guide us in the solution of this question for an average consumer. If, however, we have a great many short-hour consumers, say in the residence section, and a few long-hour consumers, it might be profitable to give them lamps of different efficiencies, though such practice often leads to serious trouble. With so many questions to deal with, it is difficult to state just how to go about it to determine what efficiency lamp should be used in any particular station.

The cost of lamps and of renewing them may be easily determined for any particular station. This may be reduced to a kilowatt-hour basis by estimating the life of the lamp on the regulation obtained in that station. To the above we must add the increased fixed cost to provide capacity for low-efficiency lamps, which is reduced to a kilowatt-hour basis by the average consumption per lamp per year in that station. Then by determining the costs proportional to output in that station we can calculate the increased cost for extra current for low-efficiency lamps. Comparing the sum of these quantities for the several lamps, we can see the effect of using the different efficiencies if we ignore the effect on the consumers. It would probably not be good practice to change the efficiency of lamps if the costs appear about the same for two efficiencies, though a gradual change of efficiency might be started; that is, we might burn a low-efficiency lamp at a little higher voltage, or burn a high-efficiency lamp at a lower voltage than rated. This could be continued until we arrived at the proper efficiency as selected. It might be good policy for us to use a low-efficiency lamp and make a reduction in rates. While we may not actually reduce rates, we may derive some benefit from the fact that the rate per kilowatt hour has been reduced.

We hear much about the higher temperature of the high-efficiency filament, which is supposed to give us a light of better quality, but I think the advantage is not wholly with the high-efficiency lamp. On nearly all of our stations a 3.1-watt lamp becomes a 3.5-watt, or lower, in 400 hours. Is it better to start with 3.1 and go to 3.5 watts in 400 hours, or to start with 3.5 watts and go to a four-watt lamp in 750 hours? The 3.1-watt lamp deteriorates more rapidly, taking but 400 hours to reach the initial temperature of the 3.5-watt lamp. If it is not removed promptly it will go to the final temperature of the 3.5-watt lamp in about 500 hours, and will probably break at about 550 hours. The 3.5-watt lamp deteriorates slowly, and if it is allowed to remain on the circuit beyond its useful life it is not so apt to cause complaint, for the reason that the decline is slow and not so likely to attract attention.

To sum up, I might say that I think the best way to answer the questions propounded is to face the situation squarely and figure it out for ourselves. If we allow the lamp salesman to do our calculating, we shall in all probability use 3.1-watt lamps. I do not say this to cast reflections on the lamp salesmen, as I think they have been only too active and energetic in advancing their side of the question. I think if more of us did our own calculating we should be using more low-efficiency lamps and giving a more uniform and satisfactory service. There are stations in which 3.1-watt lamps can be used to advantage, but I think the use of 3.1-watt lamps has been forced far beyond the point that would be determined by true economy and satisfactory service.

## FRANCIS W. WILLCOX

The importance of determining the best lamp efficiency can hardly be over-estimated, for the selling side of the lighting business is one wherein much money can be lost or gained. It is all well enough to give the expense side full attention; the savings, however, that are effected in station operation through the expenditure of goodly sums for reconstruction can be quite readily offset by the effect of improper lamps. Through the supply of lamps of too low efficiency, or through general neglect of lamps,—by failing to supply free or low-priced renewals and thereby permitting all kinds of lamps to go into service—managers are led into price reductions, to the giving of allowances, to indiscriminate rate-making and kindred evils that seriously reduce profits. Furthermore, the introduction of the electric light into stores and residences is by the same causes retarded, and long hours of use by consumers (the most profitable character of service) is discouraged. This question, therefore, comes home to every central station, and there should not be one that admits, either by word or by the act of failing to control and regulate the lamps in use on its circuits, that it is indifferent to the question of the best lamp efficiency.

### DEFINITION OF THE TERM "BEST EFFICIENCY"

It is necessary, first of all, to define the meaning of the expression "Best Lamp Efficiency." It does not necessarily mean the highest efficiency, nor the efficiency that gives the longest lamp life. The term "best" as used here means, as I take it, the most desirable; that is, the efficiency that will give the most desirable results.

Now, what are the most desirable results? It is easy to answer this question. Electric lighting is a commercial business, engaged in for the purpose of making money, and the most desirable results are those that yield the greatest net money return; or, briefly, the most desirable results are *Net Earnings.* The question reduces itself, then, to what efficiency of lamp in central-station service will secure the greatest amount of net earnings.

Before proceeding with the discussion it will be well to have other definitions and agreements clearly stated.

*First* of all, the lamp unit for the general discussion will be the standard sixteen-candle-power, 100-volt to 125-volt lamp. Other units of candle-power will be considered subsequently.

*Second*—The efficiency will mean the watts per candle taken by the lamps at starting; that is, the initial efficiency.

*Third*—The lamp life considered will be what is known as the useful life; that is, the life to the point where the lamp has dropped to eighty per cent of initial candle power. This conforms to standard practice of the day.

*Fourth*—The light is assumed to be sold by meter on the kilowatt-hour basis.

*Fifth*—Lamps are assumed to be supplied, either free, or at such a low price to consumer as to give the central station entire control of the matter.

Free lamp renewals is, first of all, standard and accepted practice of the most successful stations, approved by leading engineers and managers; and the reasons for this were fully given in the paper presented by the writer at your last year's convention. Aside from this, however, free renewals or control of lamps must be assumed if a station is to decide the question of the best lamp efficiency; for without free renewals, or lamps at a very low cost, how can any station secure the use of that efficiency determined as best? Experience has shown that where the consumer buys the lamps, low-efficiency lamps are invariably used, and lamps are never renewed except when broken. We shall later see additional reasons for the necessity of free lamp renewals where a station desires to select and put in service those lamps having the best efficiency for its conditions.

### THE COST OF LIGHTING

The cost of lighting may be divided into two items: The cost of the lamp and the cost of the current; the latter cost can be taken to include all expenses, fixed charges, etc.

### USEFUL LIFE AND LAMP COST FOR THE DIFFERENT EFFICIENCIES OF THE SIXTEEN-CANDLE-POWER LAMP

The cost of lamps varies for a given price of lamp with its efficiency. Assuming that lamps are renewed at the end of their useful life, we have the variation of lamp life and lamp cost per kilowatt-hour for different efficiencies of the sixteen-candle-power lamp given in Table I and plotted in the curves of Figure 1. These values of cost per kilowatt-hour are deduced from the formula Lamp Cost per Kilowatt-Hour =

$$\frac{\text{Cost of Lamp}}{\text{Efficiency} \times \text{Candle power} \times \text{Useful Life}}$$

## TABLE I

### USEFUL LIFE AND LAMP-RENEWAL COSTS PER KILOWATT HOUR FOR SIXTEEN-CANDLE-POWER, 100-VOLT TO 125-VOLT LAMP AT VARIOUS INITIAL EFFICIENCIES.

(Lamps renewed at end of useful life.)

| Efficiency in Watts per Candle | Total Watts | Useful Life in Hours | Lamp-Renewal Cost per Kw.-Hour in Cents. (Lamp Price, 16c.) | Lamp-Renewal Cost per Kw.-Hour in Cents. (Lamp Price, 20c.) |
|---|---|---|---|---|
| 2 | 32 | 55 | 9.35 | 11.65 |
| 2.1 | 33.6 | 70 | 6.8 | 8.5 |
| 2.2 | 35.2 | 89 | 5.12 | 6.4 |
| 2.3 | 36.8 | 110 | 3.95 | 4.94 |
| 2.4 | 38.4 | 136 | 3.07 | 3.84 |
| 2.5 | 40. | 166 | 2.41 | 3.01 |
| 2.6 | 41.6 | 200 | 1.94 | 2.43 |
| 2.7 | 43.2 | 236 | 1.56 | 1.96 |
| 2.8 | 44.8 | 282 | 1.26 | 1.58 |
| 2.9 | 46.4 | 336 | 1.02 | 1.28 |
| 3.0 | 48. | 400 | 0.83 | 1.04 |
| 3.1 | 49.6 | 470 | 0.69 | 0.86 |
| 3.2 | 51.2 | 550 | 0.57 | 0.71 |
| 3.3 | 52.8 | 639 | 0.47 | 0.59 |
| 3.4 | 54.4 | 738 | 0.4 | 0.50 |
| 3.5 | 56. | 846 | 0.39 | 0.42 |
| 3.6 | 57.6 | 965 | 0.29 | 0.36 |
| 3.7 | 59.2 | 1090 | 0.25 | 0.31 |
| 3.8 | 60.8 | 1227 | 0.21 | 0.27 |
| 3.9 | 62.4 | 1374 | 0.19 | 0.23 |
| 4. | 64. | 1500 | 0.17 | 0.20 |

### IS OPERATING COST THE BASIS

The question might be asked: Why is not that efficiency the most desirable which secures the lowest operating cost; that is, the lowest cost of lamp renewals and cost of current to the station. The answer is:— It would be the correct basis were light sold by the lamp hour. Here the efficiency of the lamp does not affect the cost of light to the consumer. The central station receives the same return per lamp whether the lamp be of one efficiency or of another, and it is obvious, therefore, that for a given number of lamps, the most profit can be made with that efficiency of lamp which gives the minimum operating cost. This would, of course, be modified somewhat by the consideration of how much additional income could be secured by increase in number of lamps through the use of higher-efficiency lamps.

Electric light, however, is not sold by the lamp hour but by the kilowatt hour. This makes a material difference in results. The efficiency of the lamp now affects the cost to the consumer as well as to the station. The use of a low-efficiency lamp decreases the cost to the station (by reduction in lamp renewals), but it increases the cost to the consumer. With a high-efficiency lamp the case is reversed; the station cost is increased and the consumer's cost is reduced.

It should be here observed that, so far as the station is concerned, having a given output in kilowatt hours to sell and being paid for it by the kilowatt hour, it makes practically no difference in the economy of the station whether it is sold in high or low-efficiency lamp units, except in the matter of lamp renewals. The case is quite analagous to the substitution of smaller candle power than the standard sixteen candle power, which is the largely accepted practice to-day, and which makes practically no difference in the economy of the station, except as to lamp renewals.

Looking at the question, therefore, from the operating-cost standpoint, the logic of the situation points to the use of the lamp that costs the least for renewals, that is, the extreme of low-efficiency lamps, the limit of which would be a lamp that never burned out. To accept this conclusion, however, we should have to assume that people could not do without electric light and that the station could invariably sell all the current it could generate; in other words, there must be a complete monopoly for electric lighting. Such is seldom, if ever, the case, and we are forced to look at the question from the standpoint of the consumer, whose interests demand a lamp of the highest practical efficiency.

I have heard the argument advanced that a station could reduce its costs by the use of low-efficiency lamps, thereby enabling it to reduce rates and thus stimulate business. Low *rates*, however, do not give these results unless they secure low *costs* to consumers. This argument, therefore, is a fallacy, since the slight decrease in rates rendered possible by the reduction in cost of the station supply with a low-efficiency lamp will not suffice to reduce the cost to the consumer, because of the increased power to be paid for. In other words, the low-efficiency lamp increases the consumer's bill more than it is lowered by the reduction in rates the station can offer from the savings in lamp renewals.

From curve in Figure 1, we see that the saving in cost to station of lamp renewals by the substitution of four-watt lamps for 3.1-watt lamps is about 52 cents per kilowatt-hour. The increased power to be paid for by consumers is 14.4 watts (64 watts less 49.4), or twenty-eight per cent. On a ten-cent rate this requires a reduction of nearly three cents, which means that the rate reduction must be six times the saving to the station. Obviously, we can benefit consumers more with a high-efficiency lamp at the old rate. If reductions to consumers are necessary, the greatest saving can be made at the least cost to the central station by a slight reduction in rates and the use of a high-efficiency lamp.

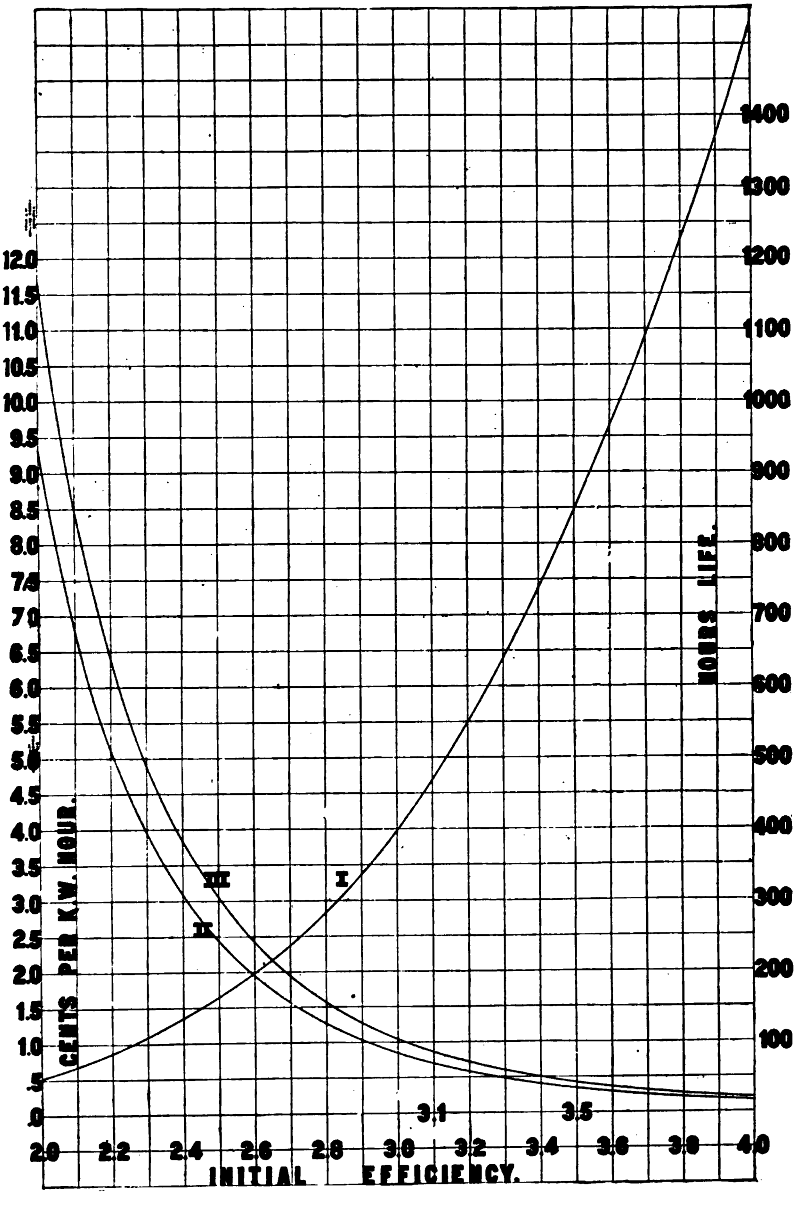


FIG. 1.—CURVE (I) OF USEFUL LIFE OF STANDARD SIXTEEN-CANDLE-POWER LAMP AT VARIOUS INITIAL EFFICIENCIES. CURVES II AND III GIVING COST OF LAMPS PER KILOWATT-HOUR FOR SIXTEEN-CANDLE-POWER, 100-VOLT TO 125-VOLT LAMPS AT VARIOUS INITIAL EFFICIENCIES, RENEWING LAMPS AT END OF USEFUL LIFE.

II—COST FOR LAMP PRICE SIXTEEN CENTS.

III—COST FOR LAMP PRICE TWENTY CENTS.

The use of four-watt or low-efficiency lamps might be desirable to increase income where very low rates have existed which it is not advisable or possible to increase; but purposely to adopt low-efficiency lamps in order that low rates may be made, seems to me like putting the cart before the horse.

The fixing of rates is a large question, and should not be made to revolve about the cost of lamp renewals. Giving low rates with the expectation of making up by the use of low-efficiency lamps is dangerous; it is apt to drive the consumers to supplying their own lamps. This may be thought to be an advantage, but the free lamp renewal policy is shown by practice and years of experience to be an invaluable essential to good electric-lighting service. Nothing should be permitted that jeopardizes it. Furthermore, the employment of low-efficiency lamps is apt to invoke municipal criticism and action and the probable enactment of an ordinance requiring the supply of high-efficiency lamps. Rates once reduced can not well be raised, and down goes the income.

It is generally best to keep rates as high as possible and secure reductions through use of the most efficient devices.

Returning, now, to the general question of the most desirable efficiency, we find, as a general conclusion, that we can not determine it from the standpoint of operating cost, as this basis will not secure the greatest amount of net earnings.

## HOW MAY NET EARNINGS BE INCREASED?

In order to arrive at the proper standpoint, it will be well to discuss briefly the general question of net earnings and how they are increased.

Net earnings are the product of per cent of profit by amount of business. There is a point of balance between these two factors at which their product, the net earnings, becomes a maximum.

The largest profits are not secured by exacting the highest per cent of profit, but, on the contrary, are generally secured by low prices and small per cent of profit, thereby increasing the gross business and swelling the total profit. In other words, we are concerned not so much as to the cost of our commodity (costs may be, and frequently are, increased with advantage); not so much with per cent of profit, but chiefly with so fixing the selling price and pushing the business as to increase the sales to the point of securing the maximum profit. Applying this idea to the question of lamp efficiency, we would say that the most desirable efficiency is not that efficiency which gives the lowest cost to the central station, or that efficiency which will return the highest per cent of profit from customers; but rather is it that efficiency which for any given rate will secure to the electric lighting company the greatest amount of profit, swelling the gross profitable business, not only by augmenting the number of lamps connected, but also by increasing the average hours used so as to bring in the fullest net returns.

With the accepted basis of sale of light by the kilowatt hour, it is plain, as I have already stated, that the efficiency of lamp used makes practically no difference in the economy of operating and service except in the matter of lamp renewals. With the consumer supplying his own lamp renewals, the station would hardly be concerned at all (within extremes) with the question of efficiency. The consumer could use any efficiency (within limits) that he pleased and it would make practically no difference to the central station, which receives its pay for the energy consumed. I say practically no difference, as the station would be concerned to the extent of having its consumers use that efficiency of lamp which would keep the consumer's bill from being excessive. The minimum cost to the consumer would be secured with that efficiency which made the sum of lamp renewals and cost of current a minimum.

## THE EFFICIENCY GIVING MINIMUM COST TO CONSUMERS

The efficiencies at which this minimum cost is secured are given by the curves in Figure 2. These curves are plotted by taking the minimum points of the curves of cost (dotted curves). These cost curves were deduced for the different power rates from the formula.

Cost of light = Cost of power + Cost of lamp = Rate × lamp efficiency × candle power × hours used + lamp efficiency × candle power × hours used × cost of lamp per kilowatt hour.

Since lamps cost per kilowatt hour =

$$\frac{\text{Cost of Lamp}}{\text{Efficiency} \times \text{Candle power} \times \text{Useful Life}}$$

the formula reduces to

$$\text{Cost of light} = \text{hours used} \times \text{rate} \times \text{lamp efficiency} \times \text{candle power} + \frac{\text{Cost of Lamp}}{\text{Useful Life}}$$

I have assumed a thousand hours' service as a basis and have deduced from this formula, in conjunction with life values given in Figure 1, the value of total cost of light for the various efficiencies of sixteen candle power at practically all the different rates for current and at two costs for lamps—sixteen cents and twenty cents. These values are plotted in the horizontal curves shown in dotted lines. The vertical (solid) lines intersecting the lowest point of these curves are the curves of lamp efficiencies which secure minimum cost of light. For example, with lights costing sixteen cents and at a rate of six cents per kilowatt hour, the curve shows that an efficiency of 2.9 watts per candle secures lowest cost. With a twenty-cent lamp cost and a ten-cent rate, the curve shows that the efficiency should be 2.75 watts per candle, etc.

The assumption made of the consumer supplying his own lamp renewals is not a true one, as the best practice, and many years of experience of central-station service, have fully demonstrated that the station should supply lamp renewals free to the consumer. Free lamp renewals has therefore been accepted as the standard practice; but in any event, as already stated, free renewals, or the control of lamps, is necessary to the purposes of this discussion.

The curves in Figure 2 show that for all the general rates of current supply (four cents per kilowatt hour and above) the minimum cost of service is secured with an efficiency of three watts per candle, or higher. Now, experience has shown that lamps of an efficiency of 3.1 watts per candle can only be kept in service by supplying lamps free or at a very low figure, well below cost. Some consumers would, of course, appreciate their value, but the average layman cannot be made to understand that he is not saving money when he is saving on the cost of his lamps. When the lamp supply is left to him, therefore, the low-efficiency, long-lived lamps prevail and lamps are renewed only when they break.

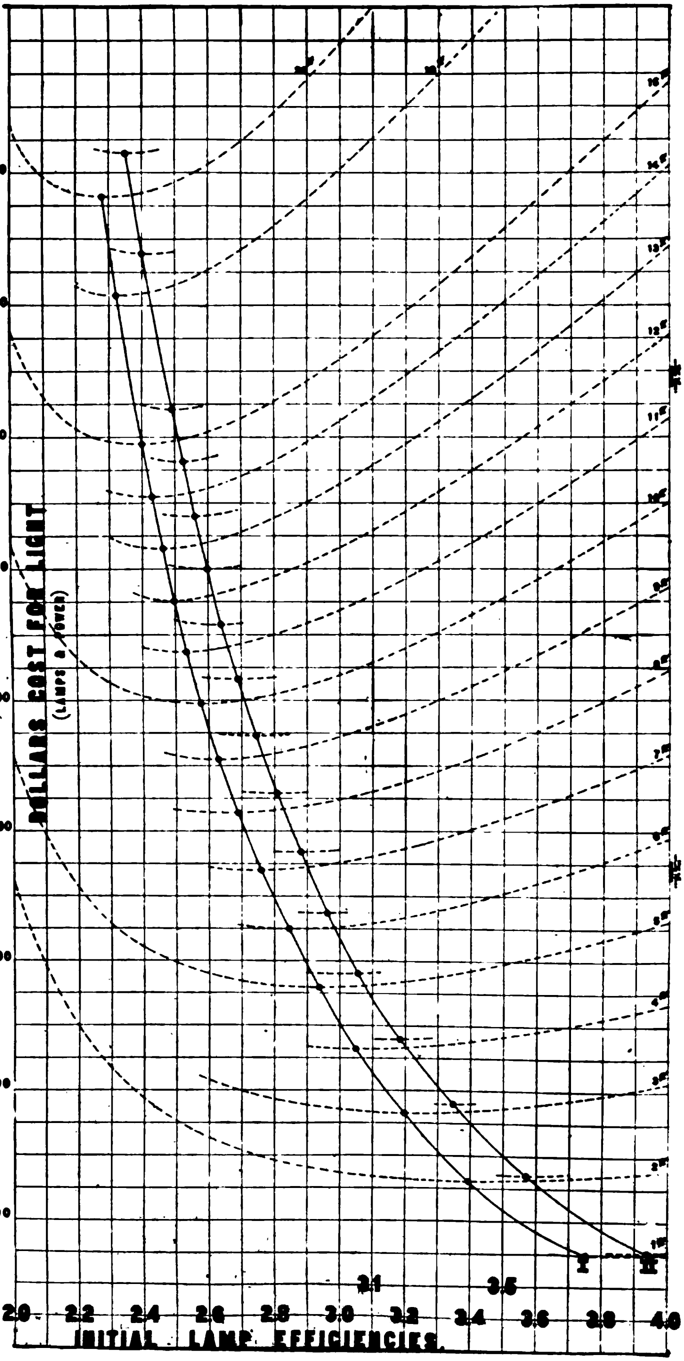


FIG. 2.—MINIMUM COST CURVES (I, II) GIVING EFFICIENCIES OF STANDARD SIXTEEN-CANDLE-POWER LAMP AT WHICH FOR DIFFERENT RATES OF POWER AND COST OF LAMPS THE COST OF LIGHT IS A MINIMUM (RENEWING LAMPS AT END OF USEFUL LIFE CORRESPONDING TO EACH EFFICIENCY).

I—CURVES FOR SIXTEEN-CENT LAMP PRICE.

II—CURVES FOR TWENTY-CENT LAMP PRICE.

DOTTED HORIZONTAL CURVES GIVE TOTAL COST OF LIGHT (LAMPS AND POWER) AT DIFFERENT RATES.

## THE CASE STATED

So, then, we have our general case summed up as follows:

We have deduced and have before us the efficiency that secures the minimum cost of light to the consumer at various rates, including the cost of lamp renewals. Accepted practice supplies the lamp renewals free and saves the consumer this part of his expense.

What lamp efficiency, then, is the most desirable? Clearly, it should be that efficiency which would, if the consumer bought his own lamp, secure him his light at the lowest cost; or, in other words, the efficiencies that are given by curves of minimum cost in Figure 2. This is true because at any lower efficiencies the consumer could afford to buy his own lamps and save money. Here is the point, then, that the station should reach in lamp efficiency.

Referring to the curve in Figure 2, the two curves representing the two lamp costs of sixteen and twenty cents, and including all rates from one cent to twenty cents per kilowatt hour, cover quite completely all practical cases. From the values shown by these curves we see that no central station having suitable voltage regulation should use any lower-efficiency lamp than 3.1 watts per candle. It will surprise many, perhaps, to note that it is at the rather low rate of four and five cents per kilowatt hour, and with a twenty-cent price for lamp that we get a minimum cost with the 3.1-watt lamp and, therefore, that for all higher rates than this lamps of an efficiency of 2.9, 2.8, 2.7, and up to 2.5 watts per candle, become the proper ones to secure minimum cost. It is plain, then, that the 3.1-watts-per-candle lamp, at the least, should be supplied in central-station service. Whether a higher-efficiency lamp should be used will depend upon the average of rates given and the special conditions of supply.

We see from Figure 2 that for rates from eight to twelve cents the 2.75-watt lamp appears desirable; for rates from fourteen to eighteen cents the 2.5-watt lamp is the one, and for twenty-cent rates a lamp between two and a half and two watts per candle should be used. It must be noted, however, that the conditions of supply come in to modify these results considerably.

Consumers whose average rates are as high as twelve to twenty cents per kilowatt hour, are consumers whose lamps average only about a half hour to an hour's use per day. They would require, therefore, several years to make the saving shown, which is based on a thousand hours' service. Such consumers, moreover, are more or less unprofitable to the station, and it would therefore be unwise for the station to increase its costs for such business by adopting a very high-efficiency lamp.

For consumers paying a rate of from eight to twelve cents, the 2.75-watt lamp is the desirable one. Such a lamp in place of the 3.1-watt lamp has already been asked for by some central stations. We may well consider whether it is not time for the adoption of a higher efficiency than the 3.1-watt. Some companies, however, consider a 2.75-watt lamp so close to the 3.1-watt lamp as to invite a compromise. It is plain, therefore, that the 3.1-watt lamp, or better, is the best efficiency for all cases where current is sold for lighting supply. Four-watt lamps and 3.5-watt lamps are not desirable unless the station regulation is not good enough for the use of the 3.1-watt lamp.

In the case of supply of light for the station's own use, or in the case of isolated plants, and in all cases where costs are below three cents per kilowatt-hour, the results point to an efficiency between 3.3 and 3.5 watts per candle as the efficiency giving lowest total cost for light. With power costs below two cents, as in the case of electric street railways, the four-watt lamp becomes the one to use.

### THE QUESTION OF REGULATION

Speaking generally, then, for central-station lighting service, the rule appears to be to use the highest efficiency permissible with the voltage regulation.

The question may be asked, How much of a variation of voltage is permissible with a 3.1-watt lamp? The effects of increase of voltage are given in the following table, in which is also given, in the second column, the efficiency at which the lamps burn with the various increases in voltage.

| Voltage per cent of Normal | Watts per Candle power | Life per cent of Normal |
|---|---|---|
| 100 | 3.10 | 100 |
| 101 | 3.00 | 82 |
| 102 | 2.91 | 68 |
| 103 | 2.82 | 56 |
| 104 | 2.73 | 46 |
| 105 | 2.64 | 38 |
| 106 | 2.56 | 32 |

The reduction in life shown is given only when the voltage is permanently kept high. This should not occur to a greater extent than four per cent, which would allow for an extreme variation several per cent higher. If voltage runs permanently as high as this or higher, then a higher-voltage lamp should be used.

We see from the foregoing table that with a pressure of four per cent to five per cent high the efficiency is only increased to about 2.75 watts per candle. Reference to our minimum-cost curve (Figure 2) shows that an efficiency of 2.75 watts per candle is not excessive, but gives minimum values quite closely for the general net rates in use. Therefore, with a regulation running permanently four per cent high we can use the 3.1-watt, sixteen-candle-power lamp and still be within the range of economical results. There should be no good reason, however, for such a permanent excess of pressure, as lamps of higher voltage can readily be obtained to correspond to the higher line pressure.

The average life (lamps left to burn until broken) at 3.1 watts of the sixteen-candle-power lamp is about 750 hours, and from our table of life variation with voltage we can, by sacrificing the candle-power limit, suffer a pressure variation as high as four per cent, reducing the actual life to 350 hours, which is long enough to compensate for the advantages of the 3.1-watt lamp. Good regulation, however, is such a valuable essential that it should be secured and maintained by all stations. Modern automatic voltage regulators like the "Tirrell" render this practical and possible. We see, therefore, that, first of all, regulation has to be very bad to exclude the 3.1-watt lamp, and secondly, that there is no good reason why bad regulation should exist in any station service and that it most emphatically pays to get rid of it.

## CONSIDERATIONS IN FAVOR OF THE 3.1-WATT LAMP

In addition to the considerations we have noted, there are other features that recommend the 3.1-watt lamp. One is the better quality of the light; its greater brilliancy and attractiveness.

The power of light to bring out colors increases with the temperature of the filament, and the 3.1-watt lamp is therefore much better suited than lower-efficiency lamps for modern illuminating work with dry goods, pictures, etc., in which color effects must be shown as far as possible in their real values.

Another feature is that a 3.1-watt lamp, although giving equal candle-power with lower-efficiency lamps, always looks brighter to the eye, and is on this account a more popular lamp.

## THE EFFECT ON RATES

As this question largely concerns the question ot rates, we might find it of interest to consider how the adoption of the high-efficiency 3.1-watt lamp, in place of a lower-efficiency lamp, affects results under the different systems of rates in force; also how the central station can cover the extra lamp-renewal cost.

Our considerations and conclusions, as stated in the beginning, are based only on meter rates. On flat rates it is obvious that the basis of sales is the lamp month, and therefore, as with a lamp-hour basis, the efficiency giving lowest operating cost should be used, modified by the consideration that a high-efficiency lamp increases the number of lamps (and consequently the income) per kilowatt of capacity.

The supply of lamps of a higher efficiency is equivalent to a reduction in rates. Therefore, with uniform meter rates varying with quantity consumed, or on the "Two-Rate Meter" system, the adoption of high-efficiency lamps would have the same effect as a reduction in the rates. Whether or not it would increase the use of light to the point of improving the net earnings, would depend upon how much influence the knowledge that a high-efficiency lamp was used would have on the consumer's burning his lamps. I should say it would have a stimulating influence. The evidence of this is the improved returns that the installation of lower units of candle power has effected and the marked improvement in the gas business with the introduction of Welsbach burners.

As regards meter rates with a minimum guarantee, the same conditions apply, with the added advantage that the guarantee can be slightly increased to cover additional cost of lamp renewals.

A generally-accepted system of rates is the one providing for the two charges that constitute the cost of supply; that is, the "readiness-to-serve" charge and the "operating" charge. The first charge is covered either by a minimum guarantee per lamp demanded (Mr. Doherty's system); or by charging a high rate for the first one to two hours' use per unit per day (Mr. Dow's system); or by charging a high rate for a given number of hours' use of the maximum demand (The Wright Demand system); or by charging a high rate for a given number of hours' use of the maximum capacity of installation (New York system), etc.

The second charge, to cover "operating" cost, is uniformly made by allowing a low rate (generally half the first rate) for all additional current used in excess of that charged for at the high rate.

The general effect of the adoption of a high-efficiency in place of a low-efficiency lamp in all these cases, will be to increase the number of units per kilowatt of station capacity. It should therefore increase the gross high-rate revenue on Mr. Dow's system and the New York system.

The consumer's appreciation of the fact that he is supplied with a high-efficiency lamp should have a tendency to make him more liberal in the use of lamps, and thereby increase the number of lamps demanded, or the maximum number used, and thus enlarge the high-rate revenue on both Mr. Doherty's and the Wright demand system.

In all these cases, then, we see that the use of high-efficiency lamps improves the high-rate revenue income per kilowatt of capacity (covering readiness-to-serve cost), and this offsets in a measure the increased cost of lamp renewals. In any case, a slight addition can be made to the price per lamp demanded or increase of number of hours for which units installed, maximum demand, etc., is charged, thus securing an increase in the readiness-to-serve charge to cover fully additional lamp-renewal cost of high-efficiency lamps. In other words, these systems of rates are so flexible as to permit of readily covering the additional lamp-renewal cost to station (with high-efficiency lamps) in the readiness-to-serve charge. All objections are thus removed to adopting the high efficiency lamps our theory requires.

## HOW LAMP-RENEWAL COST MAY BE OFFSET

Looked at in another way, it is as if the station manager should say: "We find it of considerable advantage to be able to provide light so that the cost to our customers will be a minimum. This requires the use of a 3.1-watt lamp. We do not want to increase operating costs by the adoption of a 3.1-watt lamp in place of the 3.5 or 4-watt lamp heretofore supplied. We do not deem it desirable to attempt to increase our kilowatt-hour rate to cover this increased cost. We find our consumer will not use a 3.1-watt lamp and pay for it direct, although such a lamp, even with its price added, gives light at a less cost than a 3.5 or four-watt lamp when supplied free. We find that the consumer, if made to buy his own lamps, will invariably use some lower efficiency than 3.1 watts. Consumers will not even pay directly simple increase of lamp-renewal costs for 3.1-watt lamps. We will, therefore, make consumers pay it indirectly, by a slight modification of our readiness-to-serve charge."

This involves no change in kilowatt-hour rates, and is therefore not apparent to the consumer, who, nevertheless, is thus made to contribute for the supply of the lamp it is to his interest to use, and which will save him on his service many times the charge he unwittingly pays therefor. This plan is, I know, not correct theory as concerns rates, since lamp renewals are an "operating," not a "readiness-to-serve" cost. It, however, solves the difficulty where it is not possible to increase the kilowatt-hour rates. I am even bold enough to suggest this as a means of covering the full cost of free renewals for stations that are guilty of making consumers buy their own lamps from supply stores, hardware stores, etc., and that plead in extenuation that they can not afford to supply free renewals, on account of the cost.

It would be the more correct basis, I admit, to increase the kilowatt-hour rate by the fraction of a cent that the cost of lamp renewals represents (See Curve 11, Figure 1). This has been done in some cases and should be done in all, but many stations either lack the courage to do it, or find it inadvisable or impractical. The other plan, therefore, is proposed. Its working is covered up and is not directly apparent, and thus should be generally feasible, as it is not open to the objection of a direct change in the rate. I can hardly lay too much stress on the necessity of free renewals, since without free renewals or complete lamp control this whole discussion is useless; and this must not be forgotten.

The effect of a high-efficiency lamp on returns from the low-rate charge covering operating cost should be the same as that given by the low-rate charge itself, *i.e.*, a liberal use of light. This is because, as before stated, the supply of a high instead of a low-efficiency lamp is equivalent to a reduction of rates. The low-rate charges that cover operating costs do not go, as a rule, below four cents per kilowatt hour, so that even on this part of the charge our efficiency determined (3.1-watt) is the proper one.

For special classes of business, like isolated plants taken on the service where current is supplied at a very low rate per kilowatt hour (three cents or lower) it is desirable to compromise on the lamp-renewal question by making the consumer pay for lamps but charging him only cost or below cost therefor. In such a case, of course the lamp efficiency giving the minimum cost to user at the rate given should be used.

## THE CASE OF OTHER UNITS THAN SIXTEEN CANDLE POWER

It was expected several years ago that the standard unit would tend to grow larger and the twenty-candle-power lamp gradually take the place of the sixteen-candle-power. Practice has, however, followed the opposite course, and the use of units lower than sixteen-candle-power is growing extensively. This is as it should be, for the best economy of lighting results, permitting as it does a better distribution with increase in number of lamps available. It is not at all improbable that in a few years the standard candle-power unit in this country may be the same that it is in Europe to-day, *i.e.*, the eight-candle-power lamp. It is still more probable, I think, that these lower units—ten candle power, eight candle power, etc.,—will be used in place of a higher efficiency sixteen-candle-power lamp than the present 3.1-watt efficiency. The introduction of lower candle-power units than sixteen is very like in its results to the introduction of sixteen-candle-power lamps of higher efficiency. These low-candle-power units have been of immense value to central stations in securing and holding business in residences and elsewhere, and their large, rapidly-growing and successful use attest the value of the argument I have advanced in this paper, namely, that it pays for central stations to secure their consumers the greatest economy in the costs of lighting service, just as gas companies are doing with the Welsbach lamp.

The determination of the best efficiency of these lower-candle-power units forms a most interesting question, hardly second to that of the sixteen-candle-power lamp.

## DIFFERENCE IN LIFE BETWEEN SIXTEEN CANDLE POWER AND THE LOWER CANDLE POWER UNITS

In the first place, it must be noted that the lower-candle-power units have a shorter life than the sixteen-candle-power lamp of the same efficiency. For the same efficiency, the life decreases with the reduc-

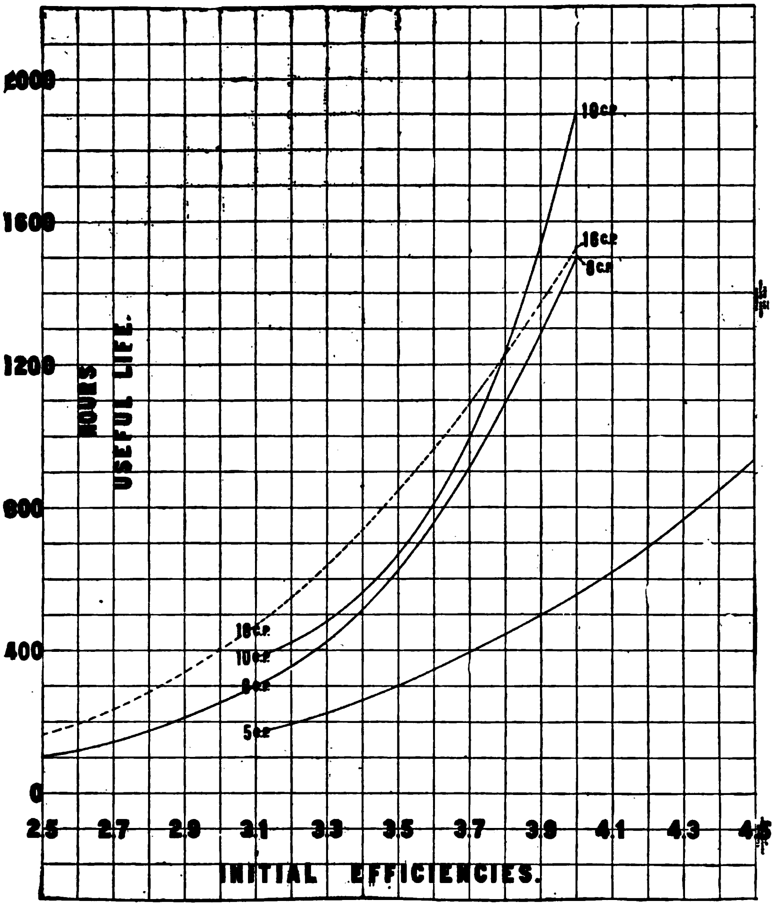


Fig. 3.—Curves of Useful Life of the Sixteen, Ten, Eight and Five Candle-Power, 100-Volt to 125-Volt Lamps at Various Initial Efficiencies.

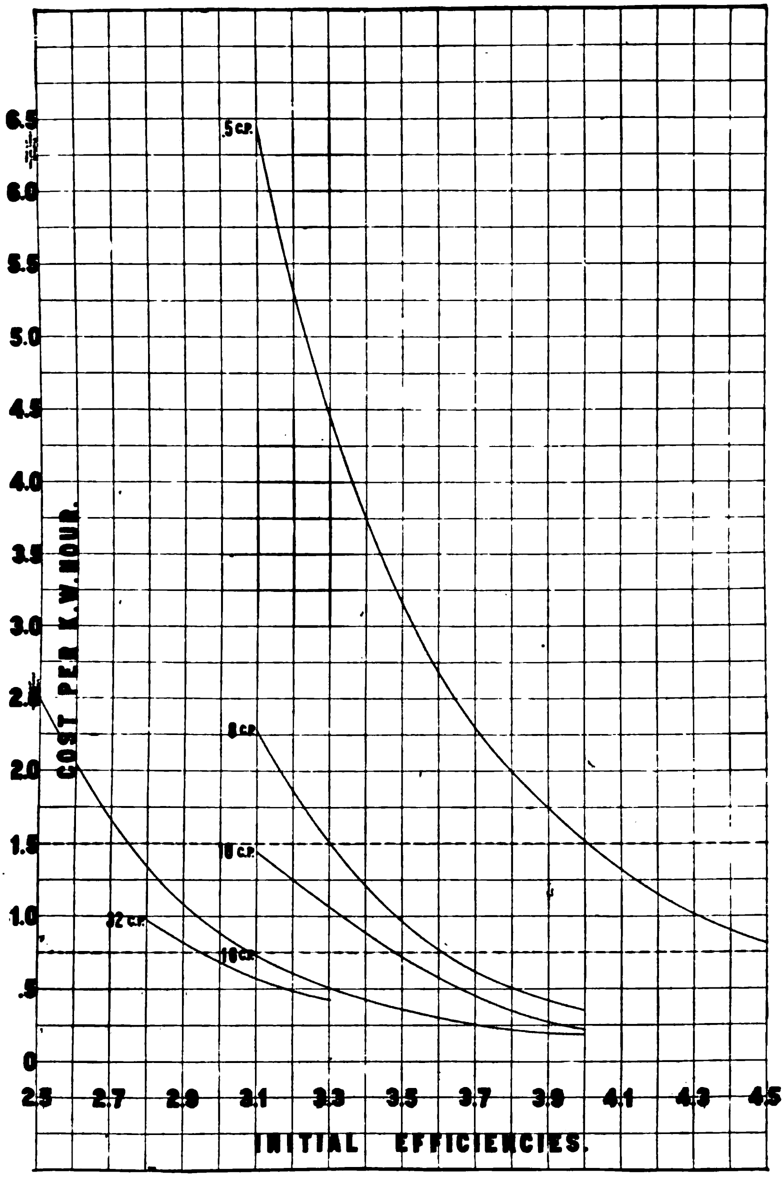


FIG. 4.—CURVES GIVING COST PER KILOWATT HOUR FOR THE FIVE, EIGHT, TEN, SIXTEEN AND THIRTY-TWO CANDLE-POWER, 100-VOLT TO 125-VOLT LAMPS (RENEWED AT END OF USEFUL LIFE.)

tion in the candle-power unit. This is shown in the following table (Table II), which gives the useful life of the various candle-power units and the cost of lamp renewals per kilowatt hour. These values are plotted in curves in Figures 3 and 4.

## TABLE II

USEFUL LIFE AND LAMP-RENEWAL COSTS PER KILOWATT HOUR FOR VARIOUS CANDLE POWERS OF 100-VOLT TO 125-VOLT LAMPS AT VARIOUS INITIAL EFFICIENCIES. LAMPS RENEWED AT END OF USEFUL LIFE. LAMP PRICES TAKEN: 17 CENTS FOR 5, 8, 10 AND 16-CANDLE-POWER; 26 CENTS FOR 32-CANDLE-POWER.

| Efficiency in watts per candle | 5-Cp. Lamp |  | 8-Cp. lamp |  | 10-Cp. lamp |  | 16-Cp. lamp |  | 32-Cp. lamp |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  | Useful life in hours | Kw.-hr. cost in cents | Useful life in hours | Kw.-hr. cost in cents | Useful life in hours | Kw.-hr. cost in cents | Useful life in hours | Kw.-hr cost in cents | Useful life in hours | Kw.-hr. cost in cents |
| 2.5 |  |  |  |  |  |  | 166 | 2.5 |  |  |
| 2.6 |  |  |  |  |  |  | 200 | 2.04 |  |  |
| 2.7 |  |  |  |  |  |  | 236 | 1.66 |  |  |
| 2.8 |  |  |  |  |  |  | 282 | 1.35 | 270 | 0.97 |
| 2.9 |  |  | 215 |  |  |  | 336 | 1.06 | 322 | 0.81 |
| 3.0 |  |  | 255 |  |  |  | 400 | 0.88 | 382 | 0.70 |
| 3.1 | 170 | 6.45 | 300 | 2.28 | 380 | 1.44 | 470 | 0.73 | 450 | 0.58 |
| 3.2 | 200 | 5.35 | 355 | 1.87 | 422 | 1.26 | 550 | 0.60 | 526 | 0.50 |
| 3.3 | 231 | 4.46 | 425 | 1.51 | 480 | 1.07 | 639 | 0.50 | 612 | 0.43 |
| 3.4 | 269 | 3.75 | 515 | 1.21 | 560 | 0.88 | 738 | 0.42 | 706 | 0.37 |
| 3.5 | 306 | 3.17 | 625 | 0.97 | 668 | 0.72 | 846 | 0.36 |  |  |
| 3.6 | 348 | 2.7 | 760 | 0.78 | 810 | 0.58 | 967 | 0.30 |  |  |
| 3.7 | 394 | 2.3 | 915 | 0.62 | 992 | 0.48 | 1,090 | 0.26 |  |  |
| 3.8 | 444 | 2.0 | 1,090 | 0.51 | 1,235 | 0.36 | 1,227 | 0.23 |  |  |
| 3.9 | 496 | 1.76 | 1,285 | 0.14 | 1,543 | 0.29 | 1,374 | 0.20 |  |  |
| 4.0 | 550 | 1.54 | 1,500 | 0.35 | 1,910 | 0.22 | 1,500 | 0.18 |  |  |
| 4.1 | 629 | 1.32 | 1,700 |  |  |  |  |  |  |  |
| 4.2 | 697 | 1.16 | 1,900 |  |  |  |  |  |  |  |
| 4.3 | 773 | 1.02 |  |  |  |  |  |  |  |  |
| 4.4 | 850 | 0.91 |  |  |  |  |  |  |  |  |
| 4.5 | 935 | 0.81 |  |  |  |  |  |  |  |  |

Since the price of all lamps is the same as that of the sixteen-candle-power, there is a limit in efficiency with low-candle-power units at which the station can afford to supply the lamp free. The income given during a life the same as the sixteen-candle-power bears too small proportion to the cost of the lamps. The following table gives information on this point:

### TABLE III

### COST OF LAMP RENEWALS WITH DATA AS TO LIFE, REVENUE RETURNED, ETC., FOR CANDLE-POWER UNITS BELOW SIXTEEN CANDLE POWER

| Class of lamp | Total watts per lamp | Useful life in hours | Cost of lamp renewals for 1,000 hours' service. (Lamp price taken at 17¢.) | Income returned per lamp for 1,000 hours' use at 10¢ per kw. hr. | Per cent of cost of lamp renewals to income returned for 1,000 hours' use at 10¢ per kw.-hr. |
|---|---|---|---|---|---|
| 5-Cp., 4-wpc. . . . | 21 | 550 | $0.31 | $2.10 | 15 |
| 6-Cp., 3.1-wpc. . . . . | 25 | 300 | 0.56 | 2.50 | 22.5 |
| 8-Cp., 3.6-wpc. . . . . | 28.5 | 760 | 0.22 | 2.85 | 7 |
| 8-Cp., 4-wpc . . . . | 33 | 1,500 | 0.11 | 3.30 | 3.333 |
| 10-Cp., 3.1-wpc. . . . | 31 | 380 | 0.45 | 3.10 | 14.5 |
| 10-Cp., 3.6-wpc. . . . | 36 | 780 | 0.22 | 3.60 | 6 |
| 10-Cp., 4-wpc. . . . . | 40 | 1,900 | 0.09 | 4.00 | 2.25 |
| 16-Cp., 3.1-wpc . . . | 50 | 470 | 0.36 | 5.00 | 7 |

The efficiency that gives equal life to that of the sixteen-candle-power lamp can therefore hardly be taken as the basis for low candle-power units.

It has been suggested to reduce the useful life limit from eighty per cent to seventy per cent or lower, allowing lamps to burn to the end of their full natural life and thus reduce the cost of renewals. The natural average life of such lamps is, however, just about the same as the useful life for practically all efficiencies higher than 3.6-watts per candle, so that there is no increase of life available.

## THE BASIS OF EQUAL LAMP COSTS PER KILOWATT HOUR

The most satisfactory plan would seem to be to adopt that efficiency which makes the costs per kilowatt hour for any unit the same as the sixteen-candle-power lamp selected. From the costs given in Table II and curves in Figure 4, we can quite readily determine this. This gives us an efficiency of 3.6 watts per candle for the eight and ten-candle-power lamps and below four watts for the five-candle-power lamps. I have included the higher-candle-power unit up to thirty-two candle power on this diagram, and we see they should have the same efficiency as the sixteen-candle-power. The adoption of low efficiency for low-candle-power units affects costs per lamp to consumers much less than with sixteen-candle-power lamps; there is, therefore, less objection to the use of 3.5 and four-watt efficiency in these units.

## THE EIGHT-CANDLE-POWER LAMP

Were the eight-candle-power lamp the standard unit in this country instead of the sixteen-candle-power, as it is in Europe, we should then deduce the desirable efficiency on the same basis that we have adopted for the sixteen-candle-power lamp. The curves in diagram Figure 5 give the efficiencies that will secure the minimum cost of light similarly to the results of the sixteen-candle-power lamps given in Figure 2. This points to the 3.6-watt lamp, or better, as the desirable one, considering the matter in regard to rates and conditions of service in the same way as we have the results for the sixteen-candle-power efficiency.

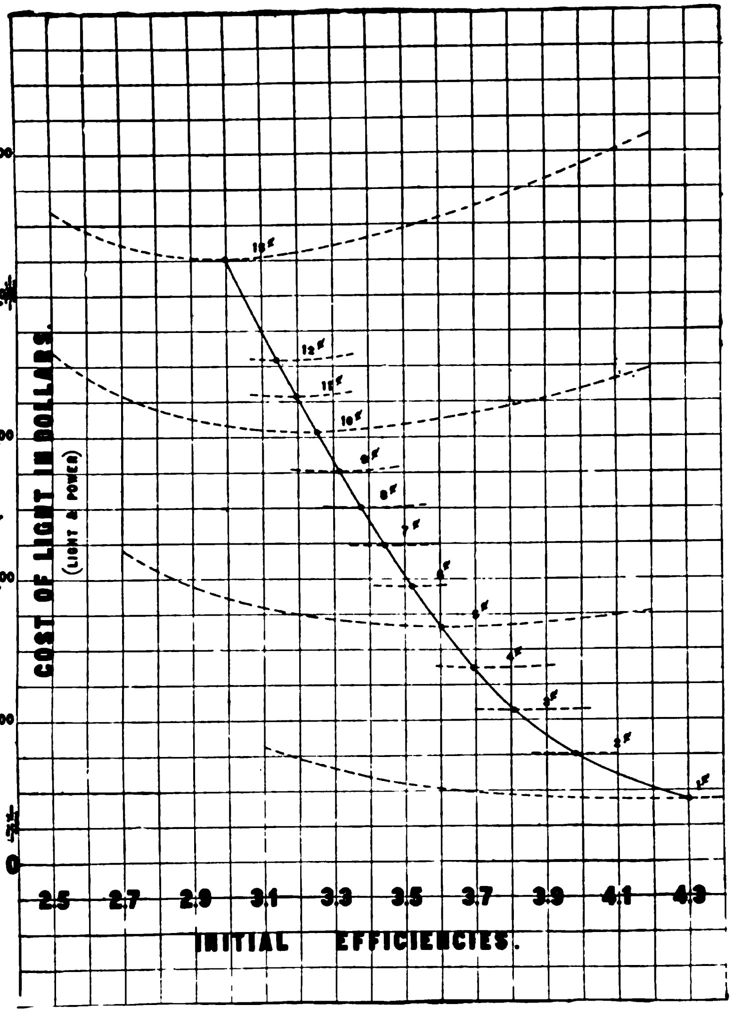


FIG. 5.—MINIMUM-COST-OF-LIGHT CURVES FOR EIGHT-CANDLE-POWER LAMPS AT VARIOUS EFFICIENCIES AND DIFFERENT RATES FOR POWER (LAMP PRICE TAKEN SEVENTEEN CENTS AND RENEWALS MADE AT END OF USEFUL LIFE CORRESPONDING TO EACH EFFICIENCY).

DOTTED HORIZONTAL CURVES GIVE TOTAL COST OF LIGHT (LAMP AND POWER) AT DIFFERENT RATES.

### THE LOWEST UNITS OF CANDLE POWER

For the smaller units of five, four, three and two candle power, extended consideration is not necessary, since they are as yet generally used only for two purposes—sign lighting, and closet and cellar lighting in residences. For the latter service they are a pure convenience to the user and therefore of value to the central station company only in popularizing electric lighting and aiding its introduction into residences, etc.

### THE CASE OF SIGN LAMPS

In sign lighting a good number of lamps are always used together, a condition that allows greater liberality in lamp renewals and in efficiency to be chosen, etc., than would be the case for general service with lamps used individually or in smaller groups. The efficiency of such lamps in sign lighting must be high enough to secure the effect of point and brilliancy, avoiding the reddish tinge which gives a dim, dull appearance. To this end we must accept a higher efficiency and shorter life than the basis of equal costs per kilowatt hour with sixteen-candle-power lamps would give us. Experience shows that a three or four-candle-power lamp, when used at approximately four watts-per-candle efficiency, gives very satisfactory service in sign lighting. Their life will average six hundred hours, and they give the desired brilliancy.

### GENERAL CONCLUSION

In general, then, we have the following conclusion:

*First*—The best available efficiency in central-station service for the sixteen-candle-power lamp is

3.1 watts per candle. Actually, the 2.75-watt lamp is the desirable one for average rates in use.

*Second*—The 3.1-watt lamps can be used to advantage even when the voltage is kept four per cent high with fluctuations going still higher.

*Third*—There should, therefore, be no central station which supplies current by meters using any lower efficiency than the 3.1-watt lamp in sixteen candle power.

*Fourth*—The best efficiency in smaller candle-power units is that which keeps the cost per kilowatt-hour renewals about the same as the sixteen-candle-power costs. This basis gives a 3.6-watts-per candle efficiency, or better, for eight and ten-candle-power lamps.

*Fifth*—Very low candle-power units, being used chiefly for sign lighting, can be more liberally treated than the basis in paragraph fourth demands. An efficiency of four watts per candle is desirable for the four and five-candle-power units, reducing this to five watts per candle for the three and two-candle-power lamps, owing to the extreme fineness of filament in so small a unit.

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NEW YORK, May 12, 1902.

HENRY L. DOHERTY, ESQ.,
President National Electric Light Association.

DEAR SIR:

In answer to your request, I beg to append a few statements having bearing on the proper efficiency of incandescent lamps, which any central station should select as the best for its purposes:

It has too frequently been the case in the conduct of an electric-lighting business that we become so much immersed in the various technicalities governing the situation that broad lines of business policy are temporarily overlooked. This should not be. Turn and twist as we may, eventually we are confronted by the fact that the central stations want customers; they are in active competition with other forms of illumination, and can only achieve full measure of success, not alone by attention to every engineering problem—I should be the last to decry good engineering—but by never forgetting that at times a slight expense may mean a heavy gain.

Advocates of electric illumination should never stand content with the fact that it is a better artificial illuminant than any other known; it should be made as reasonable in cost as is possible, to achieve the widest popularity. This is not the day of a small business with a large percentage of profit. What action should then be taken in a case where the extension or restriction of a business hangs on frequent or infrequent lamp renewals? Would it not be wiser to have the customer use a 16-candle-power 50-watt lamp, rather than a 64-watt lamp? Are there many exceptions to the rule that if a central station should reduce 25 per cent the watts necessary to produce sixteen candle power, the saving to the customer would result in a largely increased business? Why then tend in the opposite direction?

Not every central station can regulate closely enough to use 3.1-watt lamps, but the result will justify the highest economy possible, without too great annoyance to the customer by reason of burn-outs.

From a strictly engineering standpoint, it would seem a simple matter for the members of the National Electric Light Association to arrive at a proper conclusion if a table were given them, the fixed factors provided, and blanks left for the variables. which each manager could insert for himself, but business policy should be ever kept in mind.

Even where conclusions coincide with business policy, they should not be too closely subdivided, since it is not commercially possible for an incandescent-lamp manufacturer to make special economies to suit every case exactly. American manufacturers are ahead of their foreign rivals because they have standardized their products, and this is as true of lamp making as of other lines.

The leading manufacturers to-day produce 3.1, 3.5, and four-watt lamps, which practically cover the field. A central station whose extreme pressure regulation is not within three or four per cent can make no greater progress during the next year than by devoting itself to this problem. Nor should the station manager forget that a broader peak inevitably accompanies a cheapening of cost to the consumer. This is a vital point, frequently given too little consideration, and while better methods of charging are adopted, the potency of the latter argument is not lessened by high-economy lamps.

The argument that low-efficiency lamps are preferable to high-efficiency lamps because finer regulation is required for the latter, is a double fallacy. The best possible regulation should be provided, regardless of lamp efficiency, if maximum satisfaction is to be afforded the consumer. Nothing is more irritating to a lamp user than variable intensity of light. Instead of using the delicacy of the high-efficiency lamp as a screen behind which to conceal slovenly management, let central-station men bring their regulation up to the highest practicable point, with a view to best satisfying their consumers; then it will not be necessary to waste energy on four-watt lamps.

There are many other arguments in favor of the high-efficiency lamp, such as investment, depreciation, with which should be included the displacement factor. The latter has received scant attention, but practice has shown it to be of great importance in the electric-lighting field. A charge of 10 per cent for depreciation, annually, does not properly show the loss when apparatus becomes obsolete by reason of improvements in the art. The greater the power absorbed by the lamp, the higher the investment, depreciation and displacement factors.

The central stations that have advocated high economy in incandescent lamps, have been, with rare exceptions, the companies that have done a large volume of incandescent lighting, and paid handsome dividends. In the light of such experience in the past, should we now go backward and increase the cost of electric lighting to the customer because of the cost of lamp renewals? Moreover, it will be found that customers can more readily be had for a white light than for a yellow one; the first-named pleases the eye.

Just a word here as to the cost of incandescent lamps; a good lamp is to-day sold for but slightly more than a lamp chimney costs. The former goes through over fifty mechanical, chemical and electrical operations, some of them requiring the highest technical skill, while the latter is made in three or four operations. Increased output has so aided the lamp-maker in reducing his cost of manufacture, that to-day a lamp sells at about one-fifth the price that most of us can remember its bringing. One of the prime factors in producing this condition, has been the employment of 3.1-watt lamps on a large scale, making cheaper lamps through larger sales, and sales made with the prime consideration of giving lighting at low cost to the customer of the central station, even though the renewals were more frequent.

Yours truly,

CONVERSE D. MARSH.

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THE PRESIDENT: These papers give a fair example of what we aim to accomplish in our programme. We aim to bring together the views of several men instead of presenting those of any one man. You can not agree with all of these views, and having several papers on the subject is pretty apt to result in a better understanding of the subject than if but one paper were presented. You would be rather inclined to lean to the views in any one paper. You now have the views of four or five men. They do not agree. The lamp manufacturers favor a high-efficiency lamp and the station men favor a low-efficiency lamp. One manufacturer is inclined to believe in low-efficiency lamps. The subject is now open for oral discussion.

MR. FERGUSON: Mr. President and gentlemen: I feel very much like complimenting Mr. Willcox on his very elaborate and carefully prepared paper. I have been intensely interested in it, although I have not had an opportunity of reading it carefully. In general, I agree with him. There is, however, one question I should like to ask him. I have always been an advocate of the lower-candle-power lamp — that is, the lamp lower than 16-cp — because I think we are coming to the time when, as Mr. Willcox has said, the 8-cp lamp will be the standard in this country; but I was surprised at the diagram on page 112 and also at the table on page 113 of this report. While I knew that the cost of renewals per kw-hour of the 8-cp lamp was more than that of the 16-cp lamp, I had never realized that it was so much as it is represented in this paper. In the curve on page 112, giving cost of renewals per kw-hour, the 16-cp lamp is shown at three-quarters of a cent, whereas the cost of renewals of the 8-cp lamp, of similar efficiency, is shown as two and a quarter cents per kw-hour. These figures are startling; one is practically three times the other. I want to ask Mr. Willcox if these curves and tables are fair; that is, whether the 8-cp lamp has had the same experience and ability expended upon its development as has the 16-cp lamp of the efficiency of 3.1 watts, and whether if more time, more energy and more ability were expended in developing an 8-cp lamp of 3.1-watt efficiency to a higher performance, we should not reach a better comparison of the two lamps than is shown by the diagrams.

Mr. Williams: I would ask how Mr. Willcox reaches the result of such a tremendous disproportion in the cost between the 8-cp and the 16-cp lamps. We understand that a commercial 8-cp lamp requires six-tenths the energy required by 16 candles, and gives half the light; of course the returns are reduced in that proportion, while the lamp cost is practically the same. Yet I fail to see how Mr. Willcox finds the lamp costs to increase four times.

While greatly interested in all the papers presented on the subject, and especially in the array of technical information in the paper of Mr. Willcox, I think the commercial problems of central-station management are perhaps more fully covered in the excellent paper of Mr. Marsh. It would seem that the object of the central-station manager should be to get just as much light — just as many units of light — from his lamps as it is commercially possible for him to get, and to give to the public for the money it pays as much light as it is possible to give. That has been the policy of our company in New York, using only lamps of the highest commercial efficiency, and it has been an unqualified success. We have applied the same policy in small places, so the comparison is not only with a large company, and the relative results have been equally good. A low-efficiency lamp in the public service is a snare and a delusion, and, apart from the illusion of an increased revenue, is to be used only to cover up inefficient management and poor regulation. In New York, the ownership of lamps, with free renewals, is confined to the company, except in the theatres and where we have to compete with private plants, where comparisons are made on the basis of plant costs and Edison prices. The reduction offsetting the lamp supply is one cent per kilowatt hour. To prevent our larger customers from purchasing lamps that are surely of low efficiency, resulting in greatly increased bills and dissatisfaction, we sell them our "area-tested" Edison lamps at less than cost; and we have been more than satisfied with the result. There are examples where the increase in the current consumed by other than our lamps has increased our customers' bills as much as 30 per cent. Less percentage often means the difference between private-plant and central-station service.

I do not accept the suggestion that the standards of light are going downward. Eight-candle lamps for sign lighting are very satisfactory; but in general illumination the desire and tendency is to go to higher units; exemplified by the higher standards of the Welsbach lamps, so successfully adopted by the gas people. Our aim should be a more brilliant unit, a whiter light, approaching more nearly the light of the Nernst lamp.

MR. MARSH: I think that what we all want are the real facts as to what lamp will give the best results under varying conditions, and I therefore hardly agree with Mr. Willcox in some of his statements. The manufacturer will prejudice his whole case if he deals in exaggerations, therefore we should all be careful to avoid absurdities. On page 93 Mr. Willcox says: "Looking at the question, therefore, from the operating-cost standpoint, the logic of the situation points to the use of the lamp that costs the least for renewals, that is, the extreme of low-efficiency lamps, the limit of which would be a lamp that never burned out." I am afraid the central-station man might say in such a case that the converse of Mr. Willcox's statement was true, and that if his argument as to using high-efficiency lamps were correct, we ought to have a lamp that would burn out as soon as put in circuit. On page 102, about the middle of the third paragraph, Mr. Willcox says: "Such consumers, moreover, are more or less unprofitable to the station, and it would therefore be unwise for the station to increase its costs for such business by adopting a very high-efficiency lamp." I take it that just the opposite might sometimes be true. If my memory is correct, our worthy president presented a case last year in the discussion of a church that was lighted only once a year. If we were obliged to light a church like that, it would be better to put in 2.5-watt lamps, and not three-watt, or even four-watt, for we should want the amount of machinery employed in such lighting the minimum amount, not the maximum.

MR. KELSCH (Montreal): I should like to ask Mr. Ferguson if he finds it profitable to use 3.1-watt lamps on the alternating-current system. I understand that he is using 3.1-watt lamps on the direct-current system, but he has a large alternating system as well, and I believe his company is using 3.5-watt lamps in the greater portion of it.

MR. FERGUSON: We are using the 3.1-watt lamp in one district of the company; not using it in general, but in one district, where the regulation is good, we are using the 3.1-watt lamp.

MR. MARSH: There is one more point I should like to bring up: what Mr. Van Ness has judged would be greatly enhanced if the lampmaker were doing what he should. Unfortunately, I am a lampmaker. Mr. Van Ness' argument would be stronger if the lampmaker had met theoretical conditions. He has been devoting so much time to the 3.1-watt lamp that he does not produce as good a 3.5-watt or four-watt lamp as is possible. If he did, it would have twice as long a life before it dropped 20 per cent from its initial candle-power as a 3.1-watt lamp now has. Theoretically, the four-watt lamp should be about four times as long-lived as a 3.1-watt lamp. This would, however, necessitate a larger bulb, as a heavy percentage of the drop in candle-power is due to blackening of the bulb. The larger the bulb, the thinner the coat of blackening, and consequently the less such blackening would obstruct the light.

THE PRESIDENT: I do not know exactly how to close this discussion. It would hardly be fair to let the man who read the last paper have the last word on the floor; and, if you agree to it, I will call on the readers of the papers to close the discussion in the reverse order from that in which the papers have been read. Has Mr. Marsh anything to say in closing his discussion?

Mr. Marsh: I have nothing more to say, Mr. President.

Mr. Willcox: First, answering the questions raised: In reply to Mr. Ferguson's question as to whether with equal efforts expended upon the 8-cp lamp as on the 16-cp lamp we should not get better results, I will say I think we should. The manufacturer expends his best ability on the lamp for which there is the greatest call, and the greatest call has been for the 16-cp, 3.1-watt lamp, which is most generally used. With the increase in demand for the low-candle-power units, there has been a decided improvement therein. It is not too much to say that the improvement in the low-candle-power lamps has been 60 to 80 per cent as the result of an increased demand, and we can reasonably expect still further improvement. I do not think we can expect that they will be improved to a point of equal quality with the 16-cp lamp, because of the mechanical difficulties with the very small, thin filament required for the low-candle-power lamps.

As to the difference in cost of the 8-cp and the 16-cp lamps, the cost per kw-hour is figured out as the cost of the lamp (17 cents) divided by the kw-hours consumed in service. In the case of the 16-cp lamp, of 3.1 watts per candle, the useful life is 470 hours. This figures out 17 cents divided by 23.5 kw-hours, or .72 cent. Now, in the case of the 8-cp lamp we pay the same money—17 cents. This lamp, however, has only 300 hours of useful life and consumes but 24.8 watts; hence we have 17 cents divided by 7.44 kw-hours, or 2.28 cents. The kw-hour renewal cost for the 8-cp lamp is therefore three times what it is for the 16-cp lamp of the same efficiency.

As to the question of 3.1-watt lamps on alternating currents, I can refer to a number of stations: for example, Hartford, Conn., where they have used a 3.1-watt lamp for a number of years on the alternating current, and have recently asked if they can not obtain a higher efficiency than 3.1 watts, claiming that the latter gives too long a life.

As to the differences between lamps of various efficiencies—3.1, 3.5 and four watts—these differences, it should be explained, are largely due to the use of one size of bulb. The manufacturer does not make any difference in the size of the bulb for the 3.1-watt lamp and the four-watt lamp, although more energy is dissipated by the latter. The theoretical values mentioned by Mr. Marsh can only be obtained by experimental determinations. The factors mentioned have lately been changed, as the result of recent tests, so that the differences between a 3.1-watt and a four-watt lamp are not so great as Mr. Marsh has stated.

Briefly running through the papers preceding my own, I will call attention to several points. Mr. Doherty says that the central-station point of view, in considering this subject, should be the cost to the station of supply of current. He deals in this way with the cost of lamp renewals: "My own views are that the efficiency of the lamp, assuming that we are using as a standard a lamp of 16 candle power, should be placed at that point where cost to the central station for supply of current just balances the cost of lamp renewals; and that when this point has been determined for a 16-cp lamp, then all the other-sized lamps should have an efficiency that would bring the cost of lamp renewals to the same point per kw-hour consumed." His position would be true for an isolated plant, or for a central station selling current to itself. The company could then afford to supply a lamp that would make the cost to the station the minimum for that service; but when selling current to the public the customer is paying for it seven, eight or 10 cents per kw-hour, and you will run up bills on the customer where the station at its low cost would not feel it. If the customer paid the same low rate as the station, you could not quarrel with this point of view. His position is to have the efficiency for lower units such as will bring the cost of lamp renewals to the same point per kw-hour consumed as with the 16-cp lamp. With a 4-watt, 16-cp lamp, this would call for about a 5-watt, 10-cp or a 6-watt, 8-cp lamp; which are entirely too low, and are not available. On page 77 he says: "The only cost I see to the electric company in using lower-efficiency lamps would be boiler fuel and boiler-room labor, and costs incidental to a larger equipment." In my opinion, these points have nothing to do with the case when light is sold by the kw-hour; you are not selling it by the lamp-hour, but by the kw-hour. You are selling so many kw-hours on 10 or on 15 lamps, and it makes no difference, except in cost of lamp renewals, which we take. You go to market with a greater or less number of units of the same total value in which you dispose of your product.

Mr. Doane's reasoning on page 78 is very curious. On this basis, each station ought to start with a given amount of apparatus, and use the five-watt lamp until it has obtained a good load, when it should change to the four-watt lamp, and then later change to a three-watt lamp, and so on, through the scale. Should business grow beyond this, they would have to increase the apparatus in the end. He says that a station manager made the statement that "he was prepared to burn 3.1-watt lamps as soon as his increasing load — increase that he could not avoid — overloaded his apparatus dangerously." I would ask if increase in the business of a station is to be avoided? I think not.

On page 80, in Mr. Van Ness' paper, dealing with the question of the most desirable efficiency of the lamp, he states as the third factor that the investment per kilowatt of his station is the basis. I do not see this. When the station is selling light by the kw-hour, the investment per kilowatt capacity has nothing to do with the matter. I do not know what Mr. Van Ness means by there being a difference of opinion among lampmakers regarding the performance of lamps on varying regulation. Manufacturers are agreed, I think, that a given percentage of increase in pressure means a certain given percentage of loss of life and candle-power. On page 82, under the head "Investment per Kilowatt Capacity," the lamp-basis argument again appears. The idea seems to be that you must sell the same number of lamps and increase the station capacity. This is really no part of the question, as we are not selling current by *lamp*-hour, but by *kw*-hour. On page 83 Mr. Van Ness says: "It will be seen by inspection that we can much better afford to increase our investment for liberal users of light than we can for consumers using their lamps but a short time." This may be true, but the liberal user of light is the most difficult one to hold with a low-efficiency lamp. In my opinion you must use a high-efficiency lamp to give satisfactory long-hour use. On page 84, in speaking of changing from 3.1 to 3.5-watts, it is stated that this would have little effect on the consumer, and that results can be better obtained by reduction in the rate. I think this is begging the question. So long as the consumer gets the result, it makes no difference whether it is by reduction in rate or reduction in power taken by the lamp. I do not think you can secure much credit by a rate reduction of 10 per cent if you raise the bills three per cent. If you adopt a low-efficiency lamp, you must adopt a correspondingly low rate to the consumer; you must make an effort to make the cost to him the same.

In the second paragraph on page 84 we find this: "It is true that we might take on more business by using a more efficient lamp, but we ought to derive considerable benefit to repay us for doing more business for a less net profit." This should be, I think, less *per cent* net profit, which is a materially different thing. On page 84 also: "It is evident that we should consider the charge to the consumer for each specific case, but for the sake of simplicity we will eliminate it by assuming that we will give a discount that will exactly balance the increase in the bills that would result if we substituted a lower-efficiency lamp for those in service." This is saving at the spigot and wasting at the bung. On page 87 he says: "Comparing the sum of these quantities for the several lamps, we can see the effect of using the different efficiencies if we ignore the effect on the consumers." That is the very thing you cannot afford to do; you cannot ignore the consumer. Again, it is stated that it may be good policy to use a low-efficiency lamp and make a reduction in rates. This question is covered in my paper, on page 94, where I show that you have to make a considerable reduction in rates to offset saving. You save one-sixth and pay out five-sixths. Then, on page 88 we find: "While we may not actually reduce rates, we may derive some benefit from the fact that the rate per kw-hour has been reduced." Hardly; since you are cutting down the rate and increasing the power consumption of your lamp, so that the cost to the consumer is still the same. If improved lamps are made—if some one comes out with a better efficiency lamp that gives equal life—you are up against it. A station manager recently told me that he would adopt a lower-efficiency lamp and reduce rates, were he not afraid that some one might come along with a higher-efficiency lamp and cut into his income. Mr. Van Ness' figure for the average life of the 3.1-watt lamp—550 hours—is not correct; it is over 700 hours. His final conclusion is: "I think if more of us did our own calculating, we should be using more low-efficiency lamps and giving a more uniform and satisfactory service." I think a great, big question mark should be put after that statement; it is certainly not an evident conclusion from his paper. The last paragraph of Mr. Van Ness' paper says: "There are stations in which 3.1-watt lamps can be used to advantage, but the use of the 3.1-lamp has been forced beyond the point that would be determined by true economy and satisfactory service." I cannot agree with this. On the contrary, we have not gone far enough, and I think the tendency is stronger to-day than ever before that we should go even higher than 3.1 watts.

MR. VAN NESS: I do not intend to question many of the statements in these papers, but I will say a few words about some remarks upon my own paper. Referring to the statement in my paper that if more of us did our own calculating we should be using more low-efficiency lamps, I am surer than ever on that point, because I believe it has been demonstrated in this discussion. A great deal has escaped Mr. Willcox with the others. As to the matter of life which he assumes—it is merely a matter of assumption—you will find that the life I assume for each lamp corresponds, and bears the same relation, to the others as does the life he assumes. It is merely a percentage to be added or deducted, as the case may be. It depends upon the regulation you have in your station. On page 93 Mr. Willcox says: "Electric light, however, is not sold by the lamp-hour, but by the kw-hour. This makes a material difference in results. The efficiency of the lamp now affects the cost to the consumer as well as to the station. The use of a low-efficiency lamp decreases the cost to the station (by reduction in lamp renewals), but it increases the cost to the consumer. With a high-efficiency lamp the case is reversed; the station cost is increased and the consumer's cost is reduced." How he can figure which is the correct efficiency by allowing both of these variables to vary at the same time, is beyond me. He assumes that both vary, and picks out some place where the total cost is lowest. I say we will eliminate one variable by assuming that we will allow a discount to the consumer that will give him the same light for the same money, then we will calculate our costs; if they are less for some lower-efficiency lamp than for renewals, then it is to our advantage to use the lower efficiency. For the 3.1-watt lamp we may eliminate one variable, but cannot eliminate the other. If we determine the cost to us of interest, depreciation and tax on additional equipment necessary to go to lower efficiency, the cost of additional current necessary to supply lower-efficiency lamps, the cost of renewals for lower-efficiency lamps, and the sum of these costs is less than the cost of 3.1-watt lamp renewals, is it not a good business proposition to use lower-efficiency lamps? On page 94 Mr. Willcox says: "Low *rates*, however, do not give these results unless they secure low *costs* to consumers. This argument, therefore, is a fallacy, since the slight decrease in rates rendered possible by the reduction in the cost of the station supply with a low-efficiency lamp will not suffice to reduce the cost to the consumer, because of the increased power to be paid for." I do not think the argument is a fallacy, but I think Mr. Willcox makes a mistake in ignoring one of the items that regulate the matter; one of the items of prime importance. That same assumption comes in. We will assume that we eliminate the cost to the consumer by giving him a discount. Then if we give him the same light for the same money and we can get it ourselves for less money, is it not a good proposition for us to use lower-efficiency lamps? It may require more kw-hours, but we are not interested in that so long as we sell the same light, get the same money for it and it costs us less to produce.

On page 94 Mr. Willcox says: "On a 10-cent rate this requires a reduction of nearly three cents, which means that the rate reduction must be six times the saving to the station." That may be true, but I should like to call your attention to the curve on page 86 illustrating table on page 85. Mr. Willcox figures that if we go to a lower-efficiency lamp we shall have to give the consumer a discount three times the decrease in cost to the station. We will say that the lamps are burning 60 kilowatts per lamp per year; that is about three hours' service per day. We will figure boiler fuel and boiler-room labor cost as one cent, and if you use 3.1-watt lamps your cost will be 100 per cent, which represents renewal cost of the 3.1-watt lamp. These black curves show the total increased cost if we go to lower-efficiency lamps. The outermost curve applies to a four-watt lamp with one cent per kw-hour fuel cost. The three lower curves represent 3.5-watt lamps. If we take the 60-kw consumption and go up, we cross the 3.5-watt lamp, one-cent fuel-cost curve first. We cross that at 80 per cent of the cost of the 3.1-watt lamp renewals. That is to say, if we had 3.5-watt lamps on that station, burning 60 kilowatts per lamp per year, with fuel cost one cent per kw-hour, it would cost us 80 per cent of the cost of the 3.1-lamp renewals to increase the capacity, pay interest and depreciation on it, and furnish extra current for the 3.5-watt lamp. What discount do we give the consumer? It is 12.9—say 13—per cent, which means 13 per cent with a decreased cost to the station of 20 per cent. If you have a greater consumption per lamp per year, the increase in total cost is greater while the discount to the consumer is the same, therefore the advantage of the lower-efficiency lamp is still greater.

If the lamp is burned but one hour per day, or consumes about 20 kw-hours per lamp per year, the total cost of using 3.5-watt lamps with a one-cent fuel cost is 115 per cent of the cost of renewals of 3.1-watt lamps. As the consumption per lamp per year decreases, the total cost for low-efficiency lamps increases; and for a one-cent fuel cost and consumption of 10 kw-hours per lamp per year, the cost of using 3.5-watt lamps is about 165 per cent of the cost of 3.1-watt lamp renewals, and the cost to use four-watt lamps is nearly three times the cost of 3.1-watt lamp renewals.

I can not see why Mr. Willcox wants to put a four-watt lamp on a church that lights its lamps but once a year. It seems to me that he should put the four-watt lamp on the consumer who burns the light all the time. Assuming one-cent fuel cost, and lamp burning eight hours a day (160 kw-hours per lamp per year), a four-watt lamp would bring us to a cost of 68 per cent of the cost of renewals for the 3.1-watt lamp. In the case of the 3.5-watt lamp the total cost is a little higher — about 70 per cent of the cost of 3.1-watt lamp renewals. In my judgment, the longer a man burns his lamps, the lower efficiency lamps we can give and allow a discount that will sell him the same light for the same money. That is the basis on which the curve is calculated: give the consumer the same light for the same money, in order to eliminate one variable and control the other.

There is one sentence on page 96 of Mr. Willcox' paper to which I call attention, where he says that it is generally best to keep rates as high as possible and secure reduction through the use of the most efficient devices. Why Mr. Willcox says this, I can not understand. It seems to me that the higher we have the rates, the more attractive our plant becomes for municipal ownership agitation, or attack by competing concerns. On page 97, the last paragraph, he says: "With the accepted basis of sale of light by the kw-hour, it is plain, as I have already stated, that the efficiency of lamp used makes practically no difference in the economy of operating and service except in the matter of lamp renewals." Now, that is a little too deep for me. If we change from 3.1-watt to 3.5-watt lamps, we shall have to increase the capacity at the station 12.9 per cent, and I think we shall have to pay the same interest and depreciation on the increased capacity that we pay on the other. It may not cost as much as the original did, but we shall have to pay some interest and depreciation, and we shall have to supply 12.9 per cent more current to furnish the same light in a 3.5-watt lamp. That is all granted in the calculation of the curves. I think all the other questions have been answered.

(Mr. Ferguson in the chair.)

Mr. Doherty: I am glad now that I made a short contribution to this subject, because it gives me an opportunity to reply to some of the arguments that have been presented in favor of a high-efficiency lamp. Mr. Van Ness states in his paper that it would be better for some of the central-station men to do their own figuring on the cost of lamp renewals. I agree with him. It is evident that few of the men in this room have stopped to figure out the cost of lamp renewals for different sizes of lamps. They have been figured out by the lamp salesmen, and we take the lamp recommended and the result is that the cost on low-candle-power lamps is high. I think Mr. Willcox will bear me out in saying that no published statements had been made concerning the efficiency of lamps that would bring the same cost per kw-hour, until I wrote him for data that would enable me to compute the efficiency for different-sized lamps required to bring my cost the same per kw-hour; so I think Mr. Van Ness is justified in his statement that we should do our own figuring. I have not had a previous opportunity of reading Mr. Willcox's paper, but I think you can sum the whole thing up in a few words in answer to his 28 pages. I can supply a consumer with more light or with the same light for less money per hour with a low-efficiency lamp than I can with a high-efficiency lamp If I can supply a customer at less cost per thousand cp-hours using a four-watt lamp or a 3.5-watt lamp, I can sell it to the customer at less cost. We are selling current, but the consumer is buying light. Mr. Willcox talks of selling current by the kilowatt. I try to give a thousand cp-hours at the lowest possible cost, and my cost is less in those stations where I use what is called a low-efficiency lamp than it is with a high-efficiency lamp. At a glance, it would seem absurd to say that the longer a man uses his lamps, the lower the efficiency of the lamp should be; and yet that is right. You have a constant charge going on for 24 hours a day and 365 days a year for interest and depreciation, therefore on your short-hour users of light you want to keep down fixed charges; and your lower-efficiency light increases the interest on your investment and increases your depreciation. This may look contradictory on the face of it, but if you will go home and figure it out, I think there will be few who will favor the use of a 3.1-watt lamp for long-hour consumers.

Mr. Willcox and all the lamp manufacturers are interested in promoting free lamp renewals; and as a central-station man I am interested in it, and am trying to bring it about in every central station with which I am connected. I believe it is proper to supply lamp renewals free; but I can not afford to spend .9 cent per kw-hour, and that is what the cost would be, generally, for a 3.1-watt lamp to supply free lamp renewals. By giving 3.5-watt lamps I am supplying the customer with more current and I cut my lamp cost down to .45 cent. I have increased my consumption only about 13 per cent at a cost of .13 cent; but we will say .15 or .20 cent; a clean gain of .45 cent for the extra cost .20 cent, so I am ahead a quarter of a cent. There is no central-station man who will readily jump in and spend .9 cent per kw-hour sold, to furnish his customer with free lamp renewals; but if you start out and figure a lamp efficiency that will not give him a cost of more than .45 cent per kw-hour, you can get to a point where free lamp renewals are very desirable. A 3.1-watt lamp will depreciate very rapidly; I do not believe its life on commercial circuits, running at high voltage, is 300 hours. You say you get 750 hours with storage-battery regulation. It is well enough to come to the convention and talk about two-per-cent regulation, but there is no direct-current plant in this country that I know of, that gets anything like a two-per-cent regulation. I do not think it is possible to have a direct-current plant with as low regulation as four per cent. I have seen statements made regarding such stations, but have never seen the stations. I mean by that that there is some point in the city where the voltage will vary more than four per cent from the maximum voltage; I do not mean taking two per cent on each side. If you run the voltage four volts high, it will take your life down to about 300 hours.

Mr. Willcox says it is best to keep rates as high as possible. I think that is a very bad policy. When you have to meet competition they don't talk the efficiency lamp you are using, they talk the cost per kw-hour. When you are charging 14 cents, and an opposition party comes in and proposes to sell at 10 cents they don't ask what efficiency lamp he will use, or whether he will furnish free lamps. It is the cost per kw-hour that I want to get down, and I want to get it down where it will be the same whether I sell current for lighting or for power. Assuming that the life of your lamp is 300 hours; there are some lamps in certain houses that are burned twelve hours—throughout the night; that means that that particular lamp is depreciated beyond its useful life in 30 days. There is no central station in this country that makes periodical lamp renewals every 30 days. I do not think there is any central station that makes them once in three months. It is not practicable to make them oftener than once in three months. In the case just cited you will have one or more lamps that may go below their proper efficiency in, perhaps, 10 days from the time when they are put up. I want all my lamps to look about the same. I am absolutely out of accord with the 3.1-watt lamp except in a plant where the cost of boiler fuel and other expenses for the increased current will amount to more than the cost of lamp renewals. I do not think the 3.1-watt lamp is desirable. I do not think a man in this room can tell the difference between the four-watt lamp and the 3.1-watt lamp with the naked eye. I do not think that the temperature of the filament necessarily affects the quality of the light. The Nernst lamp has a temperature of filament that gives a white light, but in the Nernst lamp a different compound is used for the filament in place of the carbon.

MR. WILLCOX: Our experiments show that it is purely a question of temperature.

MR. DOHERTY: I do not agree with you on that, and I think I can demonstrate it. I know that the Welsbach light can be adjusted to give a whiter light, and I know it has not so high a filament temperature as one of these carbon filaments. What the lamp engineer should do is to work toward obtaining selected rays that are desirable, and not attempt to produce temperatures of filaments that destroy the useful life of the lamp.

MR. WILLCOX: I think Mr. Calvin W. Rice, of New York, can give us some information on this subject.

MR. RICE: Mr. Wurts has been working on that for many years, and I will give way to him. The question, Mr. Wurts, is whether or not the temperature of the filament in the incandescent lamp, 3.1-watts, is higher than the temperature of the Nernst-lamp glower; and whether the peculiar light given by the Nernst lamp is due to the temperature or to something else.

Mr. A. J. Wurts: I think the light is due to the material. I cannot prove this exactly, but that has been my impression all along. The temperature, we know, is high—2,500 degrees centigrade—but I think the material has a great deal to do with the quality of the light.

Mr. Willcox: Experiments made in our laboratory show that the Nernst filament operates at a high temperature. Its material is of a more refractory nature than the carbon filament, and admits of a higher temperature with the same rate of depreciation; but it is its temperature alone that determines its high radiating value.

Mr. Rice: The light given by any incandescent material is measured by its emissivity, or the optical effect on the retina, and that is determined by the length of the light waves or number of vibrations per second. The number of vibrations per second emitted varies with the temperature. The higher the temperature, the whiter the light and the better the efficiency. The 3.1-watt incandescent lamp has as high temperature as can be maintained with a practical life. The Nernst lamp has a higher temperature than the carbon of the incandescent lamp, therefore gives a whiter light and is more efficient.

Chairman Ferguson: Does Mr. Rice wish to convey the idea that the quality of the light is determined by the temperature, or not? You mean the quality is determined by the temperature?

Mr. Rice: I must explain that my association with the Nernst lamp company does not exceed 20 days. I am talking from my understanding of the pure physics of the subject and that of the number of vibrations per second of an incandescent substance. The Nernst-lamp filament — or glower, as it is called — does actually have a higher temperature, producing a light that is whiter. The rays emitted from the sun must be from a substance of still higher temperature. That is all there is to it, as I understand it. I should like Mr. Wurts to explain, from a scientific point of view, what is the actual difference in temperature, in degrees centigrade, between the incandescent filament of these lamps and the Nernst lamps. If Mr. Willcox can answer the question, it will solve the whole subject. Do you know the temperature of the 3.1-watt lamp filament?

Mr. Willcox: It runs from 1,300 to 1,800 degrees centigrade, if I remember correctly.

Mr. Marsh: It does not follow that Mr. Rice's statement contradicts Mr. Wurts' statement; they may be entirely in accord. Mr. Rice has stated that the nearer we approach the violet end of the spectrum, the greater the number of light waves. This by no means contradicts Mr. Wurts. The light per unit of surface given off by the glower or filament depends upon the character of the surface. There must of necessity be some difference between the emissivity of the Nernst-lamp glower and the incandescent-lamp filament. Mr. Rice's statement is physically correct; Mr. Wurts' statement may likewise be correct as concerns the Nernst glower.

Mr. Williams: May a non-technical man suggest that the higher the voltage applied to an incandescent lamp, the more brilliant the lamp appears?

Mr. Doherty: I do not think that the filament temperature is what gives us the selected rays; it is the material and the surface of the material. You can take any filament, and if it has a rough and dark coating you will not get a good light, but if it has a smooth lustre on the surface you will get a good light. If it has a good finish and uniform cross section, you can raise it to an efficiency of one watt per candle, and that must bring it to a higher temperature than the Nernst lamp, and yet you will not get the same white light that you get from the Nernst lamp. I am sure that the whiteness of the light does not depend upon the filament temperature, and I think Mr. Wurts and Mr. Rice will agree with me. If they do not, I should be glad to have them correct my statement.

Mr. Wurts: I agree with these remarks entirely. I have found that a change in the material used in the glower changes the quality of this light, apparently without any change in temperature; and that would indicate that the material has a great deal to do with the quality of the light.

Mr. Rice: Mr. Doherty is basing his argument on the cost per kw-hour. I think that affects every one in the room. He is basing his argument particularly upon the average cost to the average person here. I do not think that the average man in this room represents a station that is delivering to its customers a kw-hour for 1.2 cents. Mr. Doherty's assumption is based on the average man representing a station that supplies power to the customer; I mean the delivering cost; the cost to the company.

Mr. Doherty: The cost of operation; the cost of maintenance ——

Mr. Rice: Total cost to get the current to the man's socket; all charges paid; cost of delivering to the consumer. I do not believe there are 10 men in this room who represent companies that deliver to the customer a kw-hour for 1.2 cents; I think it is nearer double that. Using that as your basis of cost, I think the argument advanced by Mr. Willcox will sound more reasonable.

Mr. Doherty: At first blush; but if I increase the consumption of my lamps, I do not raise my future cost of office rent, executive salaries, superintendence, and a hundred and one fixed costs that go on regardless of the amount of current sold. There is only one true way, and that is to figure cost proportional to your increased output. It does not cost any more to read a meter if you have some consumption than if you have none. I think the cost I stated would be absurd for all cases. In one station with which I am connected, my cost for taxes alone are nearly a cent a kilowatt—or were when I first took hold of the station—but I am not going to raise my taxes by adopting this method. I should not raise them at all, no matter how much the capacity were increased, as the taxes are assessed on the value of the stocks and bonds. The error that Mr. Willcox makes is that he does not figure out those costs that are proportional to the increased cost. We have got to distinguish between costs that are incidental to readiness to serve and costs incidental to operation. I have to take the cost to the consumer, or cost per kw-hour; but we are not particularly interested in that; the matter of fixed charges is what concerns us mostly. Maybe they will be half a cent per kw-hour. With the constant operation of the stations these are not so great; but where we run a lamp but one hour in the month, for example, they would be enormous. We are considering the proportional cost necessary to lower-efficiency lamps. I have been figuring out the matter for the various plants with which I am connected, and, outside of one plant, I do not figure that we can use the 3.1-watt lamp.

CHAIRMAN FERGUSON: In your remarks, are you not thinking only of the company you represent and forgetting the poor customer?

MR. DOHERTY: No; I beg your pardon ——

CHAIRMAN FERGUSON: Your figures are based on cost of production, and not based on the price to the customer. If you increase your consumption from three to four watts, you increase the bill to the customer thirty-three and one-third per cent, while you may effect some saving in the operation of the plant.

MR. DOHERTY: The customer is buying light. If it costs me less per thousand cp-hours to sell him light with a 4-watt lamp than it costs me to sell him light with a 3.1-watt lamp, I can sell at a less price. There is some certain lamp efficiency that gives me the least cost per thousand cp-hours. I can generally get the cost lower by using a lower-efficiency lamp than by using a higher-efficiency lamp.

CHAIRMAN FERGUSON: You forget that the thing the customer is interested in is the amount of money he has to pay; not the cost per kw-hour, but the total cost of his electric-light service. While you may be able to sell the current at nearly the same price per kw-hour, you have at the same time increased the amount of current necessary for the customer to use to get the same electric-light service, and his bills have therefore increased thirty-three and one-third per cent beyond what they were for the high-efficiency lamps.

MR. DOHERTY: I can supply the consumer with a thousand cp-hours at a lower cost to me with a low-efficiency lamp than I can with a high-efficiency lamp. If I can supply the consumer with a thousand cp-hours at a lower cost to me with a low-efficiency lamp, I can sell him illumination cheaper than I can by using a higher-efficiency lamp. If the customer is getting the same amount of illumination for less money, he has no kick coming. If I am saving money on operation, and can furnish him more light for less money and still make more profits, I have no objection, and we are both satisfied.

CHAIRMAN FERGUSON: I do not admit that you can sell the same number of lamp-hours for the same money as before.

(Messrs. Ferguson and Doherty then drew diagrams on the blackboard, illustrating their individual ideas upon the question, and there was a protracted discussion between them, which was too animated to be recorded by a single reporter.)

MR. GILCHRIST (Chicago): Mr. Doherty admits that with a lower-efficiency lamp the customer will use 13 per cent more kw-hours than with a high-efficiency lamp; he also, as I figure, estimates that his saving would be approximately .31 cent per kw-hour in his cost of operation. Now, if Mr. Doherty is willing to sell current to his customers at so low a rate that .31 cent per kw-hour will amount to over 13 per cent of it, it is cheaper for him to use the low-efficiency lamps. That would mean selling current to his customers at practically two cents per kw-hour.

MR. DECAMP: Mr. Ferguson admitted that the figures presented by Mr. Doherty were in the main correct, but contended that while he was reducing the cost to himself he was increasing the bills to his customers, which every station man is interested in guarding against. Mr. Doherty's figures show that in one instance his cost will be 1.3, and in the other 2.2. If these figures are correct, I think that Mr. Ferguson is wrong in his conclusions. For instance, if you take the arbitrary method of doubling your cost as your selling price, under Mr. Doherty's figures the customer would pay 3.60, while in the other case he would pay 4.40. Of course the gross revenue would be decreased, but it is a well-established fact that any decrease in price to the consumer will sooner or later result in an increase in volume of net revenue.

MR. WILLCOX: Mr. Doherty, in order to make a saving, has to reduce his rates from eight cents to seven cents.

(The meeting then adjourned.)

## THIRD SESSION

The meeting was called to order by President Doherty at ten minutes after eight o'clock, and the first business was announced to be the reading of a paper by Mr. Irvin Butterworth, of Denver, entitled "The Taking Care of Consumers' Complaints."

# THE TAKING CARE OF CONSUMERS' COMPLAINTS

The management of the Denver Gas and Electric Company is convinced that no time or money is spent to better advantage in the conduct of a gas or electric-lighting business than that devoted to the giving of prompt, thorough and satisfactory attention to all complaints and requests received from consumers. In the case of a quasi-public corporation, popularity is almost synonomous with prosperity, and nothing contributes more to the former than the patient hearing of customers' complaints and requests, and prompt and careful attention thereto. It is said that the Chinese offer sacrifices to the Devil because the Lord is already on their side, and on a similar theory an hour spent in trying to satisfy one disgruntled consumer is a much better use of time than devoting it to the entertainment of customers who are already friendly. The manager of a gas or electric-light company must also bear in mind the naturally hostile attitude of the average citizen toward quasi-public corporations, and nothing can so quickly establish cordial relations between a company and the community as painstaking and courteous treatment of each individual consumer, however unreasonable, or however small his consumption. Each consumer, however small or obscure, has a certain influence on a certain element in the community, and to send him forth with a good feeling toward the company and talking well of it among his friends, is surely worth the time and effort required to put him in this frame of mind. There is a wide difference, measured in its effect upon the company's welfare, between the extremes of abuse and praise on the part of even its humblest and most unreasonable customer. The greatest prosperity and the smoothest sailing will be found to lie along the line of best individual treatment of customers, irrespective of the price and quality of the product supplied, and no manager should rest easy so long as he knows there is a single dissatisfied customer on his company's books. The writer recently devoted an hour of his time, together with that of his chief complaint clerk, to satisfying the doubts of one of our most obscure and least influential customers, whose bills did not average one dollar per month; and we consider that our time was well spent.

In carrying out in practice the foregoing theory, the Denver Gas and Electric Company has in operation a very complete system for receiving, recording and attending to complaints and requests received from its customers, which we regard as one of the most important "bureaus" of our office. It is in personal charge of what we call our "order clerk," whose sole duty it is to receive complaints and requests from customers and have them promptly and satisfactorily attended to. He is designated as "order clerk" rather than *complaint clerk*, and the sign over his window reads "Orders" rather than *Complaints*, because, while we encourage customers to make their complaints known, we want each one to think that his is the only complaint made. It certainly does not help a company's reputation for careful and accurate work and fair dealing to have it known and advertised that a special department must needs be maintained for taking care of complaints; nor does it lessen the consumer's real or imaginary grievance when he comes to the office to protest, for instance, against the size of his bill and finds that so many others are suffering from the same injustice (?) that the company has found it necessary to establish a separate department, with a special corps of clerks, for attending to them.

The consumer, therefore, who appears at our office to enter a complaint or request, is politely shown to the "Order Window," which is conspicuously labeled and prominently located. If space would permit, the order clerk would be provided with a separate and closed room in which all complaining customers could be received and seated, and thus be treated with a degree of courtesy and consideration that would of itself have a mollifying effect; while, at the same time, other customers waiting outside or attending to other business at adjacent windows, particularly new applicants for service, would not overhear the making of complaints, accompanied, as they sometimes are, by tirades against the company.

All complaints received at the office, personally, or by telephone or mail, are referred at once to our order clerk, who enters them in a large book so ruled as to show the reference number of the complaint and date and hour of its receipt, the name and address of complainant, the character of the complaint, the name of the employee sent to remedy it, the time such employee is sent, the time the complaint is reported as remedied and the work done in remedying it. An order is then immediately filled out, corresponding to the entries in the book, and turned over to the shop force for prompt attention. In urgent cases the complaint is telephoned to the shop for immediate attention, followed by a confirming order. When the workman has attended to and remedied the complaint, and while he is still at the premises of the complainant, he fills out the remaining blanks on the order, showing the cause of the trouble, his method of remedying same, the date and his own name, and secures the signature, at the bottom of the order, of the complainant, or of a responsible member of his family, certifying that satisfactory attention has been given. The order is then returned to the order clerk, who enters the facts on his record book, above described. He then fills out and mails to the complainant a return postal card, worded as follows: "On...... ·........, 1902, you reported...................... Kindly fill out this return postal card stating whether the matter has been attended to to your entire satisfaction. Your prompt reply will be greatly appreciated. Very truly yours, THE DENVER GAS & ELECTRIC CO." The reference number is put on each of these cards before sending them out, in order that responses not signed may be identified, and those that are returned are checked off on the record book. Of course many of the cards are not returned, but many of them are; and most of these report the trouble to have been satisfactorily remedied, many of them expressing thanks and appreciation. Occasionally one comes back with the statement that the trouble still exists or has not been satisfactorily attended to. In such cases a second order is made out and sent to the shop for immediate attention, with proper caution to the workman taking the order. The returned postal card is then attached to the original order, and after the second order comes back with the notation that the trouble has been remedied, the workman that attended to the original one is called upon by the order clerk to explain his failure to have properly remedied the trouble. Occasionally such derelict workman is brought on the manager's carpet and properly disciplined for his remissness. In this way each man knows that his work is under the review of the management, and a high degree of efficiency on the part of the workmen has thus been developed. It is, of course, the duty of the record clerk to see that a report is turned in within a reasonable time on every order that is sent out for attention.

The system of entering in chronological and numerical order the details of each complaint and request, and the attention it receives, enables us, among other things, to refute satisfactorily such statements as "I telephoned you last month to come out and re-read my meter, but you never did it;" but the best feature of the system is the sending of the return postal card, which almost invariably pleases the customer and creates the desired impression in his mind that the company is, after all, interested in giving him good service and values his patronage.

## DISCUSSION

THE PRESIDENT: Are there any remarks on this paper?

MR. ISRAEL (Philadelphia): I would ask if the complaints are principally about bills, or whether they relate only to electrical work, like replacing fuses or repairing sockets, and work of that kind.

THE PRESIDENT: I will reply by saying that they usually relate to unsatisfactory service or to high bills, and matters of that kind. All these matters are entered as complaints. If it is a high bill, and they want the meter re-read, we read the meter again and notify the customer by postal card of the re-reading. The principal thing that it was desired to bring out in this paper was the value of this return-postal-card system. We have on our books about thirty-odd thousand consumers, and, necessarily, we have a great many men to take care of complaints. The system was inaugurated as much to check the work of these men as to satisfy the consumer. The result of the return-postal-card system was most gratifying, and nothing we have ever done has so pleased the public and brought us so much commendation as this return-postal-card system, which enables us to learn if everything has been done to the consumer's satisfaction. These cards sometimes come back to us with the most profuse thanks for our attention, etc., etc. Mr. Butterworth, our manager, is a very efficient man on consumers' complaints. He wrote the paper that has just been read to let you know how successful we had found that system. The return-postal-card system is a good thing, and worth adoption.

MR. ISRAEL: We have a similar system; but what we call the Inspector's Records relate only to electrical work.

THE PRESIDENT: We cannot record it unless the inspector reports the matter at the office as he is instructed to do; and if he fails three times to report a complaint, we discharge him; we discharge him if he fails to report a complaint given him three times in one year.

MR. ISRAEL: We have adopted a Consumers' Complaint Form, and we supply our outside men with that form, so that when they receive a complaint of unsatisfactory service or of high bills, they fill out the form and return it to the office. There is a detachable slip that is kept as an office record, by means of which we can follow the complaint to see that it receives proper attention.

Mr. Williams: It is interesting to hear that the return postal card has been successfully used. Some years ago the New York Edison Company adopted the same method, providing each customer a return postal card, intending its renewal as used. The customer simply had to tear off the card, state his complaint, and mail it, yet I don't believe one-half of one per cent ever came back. We have found that the best way of attending to complaints—and preventing them—is to make a list daily of every one received from any part of the city, and for any class of service (including our series arc lighting), and then learn the employee that is in any way responsible. Two years ago there were perhaps a hundred of all kinds daily; at present it is rarely the case that more than four or five are received in the course of a day. The care of bill complaints has been specialized in our company. Not less than 95 per cent are without any basis whatever, other than that the customer *thinks* his bill high, which is a condition more often met satisfactorily by a man's manner—by what he seems to believe himself—than by what he actually says in explanation. An agent—necessarily a sympathetic man—would sympathize with the complaining customer, with the result, almost always, that he felt more prejudiced against the meter than when he made his complaint. We therefore relieved our agents of this work, and organized a separate department of men who, first, had sufficient technical knowledge to understand and believe in the meter (an essential on the part of the man who must defend it); we then gave them opportunity for a fairly broad commercial training, for acquiring tact, common sense and resource, and the result has been very satisfactory. It is now a rare occurrence to lose a consumer because he is dissatisfied with the company's charges or with the service otherwise.

Mr. Gilchrist (Chicago): There is one class of complaints with which I presume you gentlemen are all more or less familiar, and I should like a little light as to how you handle them. As consumers yourselves—possibly gas consumers—you know that you will stand a good deal before you will take the time and trouble to go to the office of the company and make a complaint; but, assuming that you do not send your clerk, but go yourself and make the complaint, the probabilities are that you are just persistent enough to feel that you want to get something off the bill anyway. You may be more than two-thirds convinced that the company is right, but you have been a customer for eight or ten years, and you have taken the trouble to walk over to the office of the company in the hot sun, and you want to get something off the bill. That kind of customer is the hardest one for me, personally, to handle. The disposition always is to cut the matter short and make the fellow feel good by rebating his bill; although at the same time protesting that you are not in any way weakening your own position, but that you waive your belief that the bill is all right for the sake of satisfying him. I should like to hear an expression from one or two of the gentlemen present as to how they handle that kind of case and whether they believe that it is a good plan to make a rebate in a case of that kind, assuming that it is a man of responsibility that has come to you, or whether you should hold him for the full amount.

Mr. Gillette (Evansville, Ind.): I want to ask, in this connection, what is the best way to deal with a customer of that kind when he is thoroughly satisfied in his own mind that the meter is incorrect, and yet the superintendent or manager is fairly sure, if not positive, that the meter is not inaccurate. If his meter is taken out and another substituted, he immediately becomes suspicious of the fact that a change has been made. I ask whether it is good policy to make such a change or to send a man to make a test and convince the customer, if possible, by mathematical calculations and instruments that the meter is accurate. It is sometimes rather a hard proposition to deal with a person dissatisfied in regard to a meter, especially where it is almost impossible to make him understand the mathematical end of it. I should like to hear some remarks on this subject.

MR. CAHOON: I think I can answer that question. The experience I have had with such customers is that you can not tell them in plain English that they lie, but you must get back at them through some system of recording; and I have found that by putting in a Bristol recording wattmeter on the premises and letting it remain with the customer during his next monthly bill, you can check up about what his consumption is and practically verify the accuracy of the meter or point out if there is any inaccuracy in the meter. You may test the meters in the ordinary manner, but can not convince the customers. If you put a recording wattmeter on, so that he can see what it is doing and check it up afterward, you will soon convince him that you are trying to treat him squarely. If you do that, you will win the battle and have him on your side, if he is amenable to argument. This method is inexpensive, and it generally takes care of such complaints.

MR. WALBANK: Replying to the gentleman who asked the question as to the method of dealing with customers that complained that their meters were fast, I should like to say that in Canada every meter, before its installation, must be government tested and must bear the government seal for accuracy. In the event of a customer's complaining, we first try to convince him that the meter does not lie. If he is not satisfied with that, we give him the opportunity of having a retest of the meter made by a government official, with the understanding that if the meter is all right he shall pay the bill and expense of test, and if slow, he shall add the corrected amount to his bill. But if the meter prove wrong the company bears the expense of test, and replaces it with a new meter, crediting the customer with the difference between the correct reading and that shown by the meter.

Mr. Bottomley: I have handled the question of which the gentleman speaks by simply going to a customer's premises, taking a potential reading, and telling him about what number of watts each lamp should consume. I then ask the customer to go to some room in his house and turn on any number of lamps he chooses, and when he comes back I tell him the number of lamps he has had burning. Tell him how many lamps he had turned on in the test, and after that he will have more faith in your statements and more faith in the meter.

Mr. McCabe (Williamsport, Pa.): With us, the greatest complaints of large bills come in October or in the winter months. A customer comes into the office and says: "My bill is too large; I did not burn that amount of light last month; the meter is wrong." I tell him the meter is not wrong. I go back over his previous bills, running perhaps over a period of six months or a year. I show him that his bill for May was only $1.50; bill for June, $1.25;

bill for September, $2.50. I then say: "I have shown you the bills for May and June. Here is your bill for October, $5.00. If your meter was right in May and June, why is it not right in October? It will not lie in October if it was right in June." If the customer is not satisfied, I send a man to look at his meter and show the customer that the meter is correct; and, without exception, I can satisfy him.

Mr. McGee (Red Oak, Ia.): I have a method similar to our friend's for handling complaints about the meter's being too fast, but I vary it in this way, and leave the testing in the consumer's hands. I go and show him how to read the meter. I tell him to turn on one or two lights when he retires at night, the night in question, and let them burn all night, and get up in the morning and read the meter, and if it is not correct we will rebate the bill. Most meters are slow on one or two lamps, and he is usually satisfied, as he thinks he is getting the best of the electric company.

Mr. Ayer: It seems to me that this is a very old story with every one of you. In my own practice in the city of St. Louis, I carried out the method of testing meters at the customer's house, when the occasion seemed to demand it, in the way suggested by Mr. Cahoon. One important factor, however, in taking care of the customers and the details of the company, seems to me to be, not in handling these complaints by a system alone—although system is a good thing to bring it into shape—but to try to take time enough to get at the real facts of the case where you have a dissatisfied customer. With a large company that might seem to be a large proposition, but it is not; I can say that from experience. In a company with 45,000 incandescent lamps and 4,000 arc lamps, I have had an opportunity to test that kind of thing, and the total number of complaints did not amount to much. It did not burden me to know personally that the results satisfied the customer, usually by personal interviews with them. It is too often the case in the central station, especially when the business becomes large, that you get too much system.. A man makes a complaint, and believes that he is fully justified in so doing. We all know that gas bills are not right, once in a while, but we think that the electric-light bills must be. A man comes in indignant—many times justly so from his point of view—and it takes something more than a mere testing of the meter to convince him that it is all right. The aggrieved customer requires to be handled by an intelligent man. You must show him the same consideration that your grocer shows you when you make complaint about the weight of your groceries or the quality of the butter. If the grocer says you do not know anything about the butter if you say it is strong, or about the sugar if you say it has sand in it, that does not convince you. He does not send a boy to tell you this, and he does not have a particular clerk to send to you; but he comes around in person, and shows a personal interest in his customers. It is too often the case that when an electric light company gets a customer on its books it treats him as an item, a being to whom to send a bill, and if the bill is not paid when due, to tack a penalty to it by not allowing the discount. It is not half the tax many men would think it for the manager to give personal attention to all complaints, and to know when he has finished with his customer that it is all right. The men that are the largest and best customers, the people you must care for, are apt to be just in their complaints from their point of view. They are apt to be wrong, of course; but it is not a simple matter to straighten them out by any set system. The postal-card scheme is all right, but it is the personal contact with your customers that is the correct thing. We like to talk to the principal when we go to make a complaint. If a man takes the trouble to go to the office of the company to enter a complaint, it has a different effect upon him whether he meets the manager or the manager is out; it has a different effect on him whether the manager calls on him or whether we send a boy to him with a notice that the meter is correct and he is requested to pay the bill. If the manager shows enough interest in his customers to see them, he can generally settle the matter satisfactorily. This seems to be a thing disregarded in many instances —this personal contact of the manager with the customer. I feel that this is an important element in the management of a company, and is entitled to very careful consideration. In private business we give attention to these details in the most careful manner, but with public-service companies these matters rarely receive the attention to which they are entitled.

MR. ISRAEL: I ask the representatives of the larger companies if they have a time limit within which they will not make a retesting of the meter?

MR. WILLIAMS: We have no fixed rule, but it is thought hardly necessary to retest under three months. The immediate circumstances usually determine our action.

MR. ISRAEL: I understood that the New York company would not make a second test within six months.

MR. WILLIAMS: We have hardly any iron-clad rules when it comes to complying with a customer's reasonable desires.

Mr. Dusman (York, Pa.): I have had a few cases in line with the complaints here mentioned. In one case we had a chemical meter installed, which had been operating in one place for over ten years; consequently, there were very low bills. We installed a recording watt-meter in its stead, and when the first bill was delivered the company was told to go to Hades and the men who managed it somewhere else, and all sorts of unkind things were said about us. I took this abuse with good grace, invited the gentleman to my office and told him I would have his meter taken out in his presence, would send it by messenger to a disinterested party to have it tested, and would not charge him anything at all for the test, the understanding being that we were to get a written report of the test and both parties were to abide by the result. This was the most severe criticism that we have ever had made upon the company in my experience; it was also the most satisfactory result when the test was made. I laid the report of the test before the gentleman and told him he owed us an apology and some expenses, but that we would let the matter of expenses go on the understanding that he would let the meter run in future and record the current consumed. I had no further trouble with the man, and in the case of a good many other complaints received since that time I have taken the report of this test out of our files and have said to the parties making the complaints: "Here is the report of the test of a meter in the house of a gentleman whom you know, who criticized and condemned us severely. I will take your meter out and do the same with it if you wish. If you are satisfied with this report, all right; if not, we will take your meter out." In that way I found I could take care of nearly all the complaints of high bills or wrong meters. Once in a while we have found creeping meters; meters that did not creep for a long time in the place where they were located, but a change in the conditions surrounding the meter—possibly a building being erected alongside that in which the meter was installed—jarring the meter and causing it to creep. In that way we have had difficulties arise; causes of complaint that we did not discover until the complaint was made. In nearly all cases I give personal attention to complaints. We have a bakery that runs motors late at night. The man that owns this plant was convinced a couple of months ago that we were at fault, because when he called up at twelve o'clock at night he could not get a man to start his motors. We convinced him that he was at fault because he did not have an employee in the place who could put in a fuse. He has confidence in the company, and respect for it, because his complaints have been attended to at once. We find it to be the very best policy to give careful and personal attention to all complaints from our consumers.

MR. AYER: I should like to have Mr. Williams explain further the system that they have for dealing with their customers in the matter of complaints.

MR. WILLIAMS: I can sum up what Mr. Ayer wishes me to say in the statement that we do everything that lies in our power to make our service satisfactory to our customers. For example, if a customer's motor bill seems high, we test the motor; and if it is inefficient, we do all we can to get the man that sold it to put in a new and good one. We examine the plant, and make any proper suggestions for higher economies. We do not stop short of anything we can do—reasonably. In lighting, if a large building and the customer is purchasing other than our lamps, we test them, and if anything can be gained, sell him Edison lamps at less than cost. Only a day or two ago we found in a certain building that the lamps used increased the bills 21 per cent above the standard of the Edison lamp; and the tenants were using the light wastefully. We quickly made a change in the lamps, and stationed a man in the building, who, going around, cut off any lamps used needlessly; and, as a result, the bills were greatly reduced. In a number of instances we have succeeded in holding our customers only by such means. Then, again, if a customer is using the incandescent light where arc lights would be better, we suggest a change, and often put in trial lamps free. We often suggest the removal of unnecessary lamps—arc or incandescent—or a reduction of the candle power: for, as many here know, the discounts depend upon the average use of the entire installation. Inner globes are renewed free of charge. Inner globes become in use very black, which entails a large loss of light and hence, if uncared for, cause much dissatisfaction and ultimate abandonment. I think, Mr. President and gentlemen, I may sum the whole matter up in the single statement that, so far as I know, we do all we can to give only the best service and to satisfy our customers in every possible way.

THE PRESIDENT: Gentlemen, we shall have to close this discussion and take up the paper by Mr. J. P. Crowley, which is entitled "What Changes Should Be Made in the Plan of Uniform Accounting."

# WHAT CHANGES SHOULD BE MADE IN THE PLAN OF UNIFORM ACCOUNTING

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## J. P. CROWLEY

In response to the courteous invitation of the president of the association, I beg to submit the following comments on the "Plan of Uniform Accounting" submitted at the last convention.

In examining the form prepared, I am impressed with the idea that a more detailed classification should have been made for the larger companies, as it is much easier to re-group into a lesser than sub-divide a few accounts into a greater number.

Would not greater uniformity result from a more expanded subdivision, thus enabling each user to regroup into a smaller number of accounts, rather than to depend on each user's expanding the system to meet his requirements and hope to retain any degree of uniformity?

The classification was made with the idea of harmonizing it with the system adopted for street-railway accounting, on the assumption that the present tendency is toward a consolidation of electric-lighting and street-railway interests. Is not the tendency rather towards the consolidation of gas and electric interests, and is not the gas business much more similar to the electric-lighting business than is the street-railway business, and, therefore, is not greater similarity of accounting methods possible between the gas and electric industries?

The simplest form of accounting would be a system of records to enable a quick determination of debits and credits and from whom receivable and to whom payable; also a careful record of expenditures for investments as distinguished from operating expenses.

The value of a more elaborate system of accounting lies in the fact that by subdividing and recording income properly it may enable quick determination to be made of how best to increase it, and to subdivide and record expenses in such manner as best to determine how they may be diminished.

A valuable method to supplement these recorded divisions is a system of periodical reports or analyses whereby income and expenses are compared with similar periods; but as our business is constantly increasing or diminishing, it becomes necessary to reduce the aggregate amount of these expenses to that unit of the whole which occasions an increase or diminution in the aggregate amount. For example, our boiler fuel will increase with an increase of output, and about proportional to our kilowatt-hour output. It is therefore necessary to reduce for purposes of comparison to the cost per kilowatt-hour output. Our cost of reading meters will increase with our increased number of meters, but may not, and probably will not, bear relation to the kilowatt-hour output; but it should bear an exact relation to the total number of meters read, and therefore the total expense should be reduced to the cost per meter read. Arc-lamp repairs, in turn, are affected by the number repaired, and should be reduced on this basis. The value of this system of accounting can be still further enhanced by all stations using a uniform method of accounting, thus enabling one manager to make comparisons of any or all income and expense items with the results of other similar stations.

Income account should be so divided that classes of current occasioning about the same expense to generate and deliver will be grouped together. Construction accounts should be so grouped that apparatus having about the same rate of depreciation should be grouped together. This would require a greater extension of the construction accounts than appears on page 9 of the report. As an example of what is meant, I will cite Division "D." This might be divided about as follows:

D (1) Real Estate Water Rights and Pole Line Right of Way
D (2) Ground Preparation
D (3) Hydraulic Construction—Masonry
D (4) Hydraulic Construction—Wood
D (5) Hydraulic Construction—Steel
D (6) Power House Building
D (7) Turbines
D (8) Electrical Equipment
D (9) Pole Line
D (10) Copper Conducters

You will notice that I have made a crude attempt to classify the different types of construction apparatus so as to enable depreciation to be intelligently computed.

There should be no depreciation on Land and Water rights, and it is probable there would be some appreciation, while the electrical equipment would depreciate, say, approximately eight per cent, and the poles, with cross arms, etc., might depreciate at the rate of fifteen per cent per year.

After passing the Income and Construction accounts we must decide upon what main divisions of operating should be kept and what the subdivisions will be.

The writer is a member of the electrical classification committee for the McMillin companies and fully recognizes how hard it is to meet the views of all, and how easy it is to criticise the plans proposed, no matter what they are; but it is only by criticism and argument that we can hope to secure a good system.

We have in course of preparation a form separating our operating expenses into five main subdivisions as follows:

(a) Generation
(b) Distribution
(c) Collecting
(d) General
(e) Interest

"A" has numerous subdivisions to enable the determination of the cost of generating each class of current, viz.:

(1) Continuous Current, Series Arc
(2) Alternating Current, Series Arc
(3) Parallel Alternating
(4) Parallel Direct

The purpose of this subdivision is to learn not only the average cost for current, but to determine the cost for each class, as we cannot sell continuous arc current at our average cost without loss, and yet we can sell our alternating or direct current at less than our average cost and make money on it. We might separate our main maintenance accounts from our operating costs, but I have been unable to see any great advantage in doing so, there being no distinct line of demarcation between operation and maintenance. Strictly speaking, all the maintenance accounts are operating expenses.

In the "Plan of Uniform Accounting," "Brushes for Dynamos," is listed as an operating expense, while "Commutators" is listed as a maintenance expense. Why this distinction is made is not clear, as arc commutators need renewing oftener than brushes on some generators.

"Miscellaneous Distribution Operating Expense" is charged on page 45 of report with Maintenance of Wagons, Bicycles, Automobiles and Harnesses. Would it not be better to do away with this arbitrary division between Operating and Maintenence, calling it all Operating Expenses?

There is no occasion for subdividing expenses unless there is some distinct advantage in doing so. On the other hand, it would be safe to divide and redivide expense accounts if the saving made possible by such division exceeds the cost of record keeping.

The committee of which the writer is a member has in course of preparation a form dividing the electrical expenses into more than 200 subdivisions.

All bills are paid by voucher and instead of using the synoptic ruled voucher journal, we use a loose-leaf ledger, giving one page to each account number. The committee was of the opinion that it was absolutely necessary to charge each main division with all the expenses which it occasions in order to determine the true generation and distribution costs, and has therefore separated costs of generation by different methods, in order to determine the relative costs of generation by steam, gas engines and water power. The form under consideration makes no provision for these subdivisions, which I regard as essential. Store Room Expense No. 32 is listed with the General Expense Accounts.

Why should not this account be closed out monthly a proper proportion being added to the cost of supplies to cover the store-room expenses. If we maintain no store room we should pay these expenses in the additional costs of the materials, and they would in that way be charged to the account for which the supplies were purchased.

The writer in no sense presumes to set himself up as an authority on accounting matters, but offers these comments, inasmuch as the form has been left open for future development, in the hope that a full discussion by the members of the association may lead to good results in which all will share.

## DISCUSSION

Mr. Isaac Smith (Cedar Rapids, Ia.): I do not recollect what was the form of accounting presented by the committee last year or the year before. It seems to me that the object of central-station accounting is not only that it shall be uniform, but that the accounts shall be such as to enable the manager to compute his costs. I am a believer in what is known as the "two-rate" system, but I have found that unless you subdivide the investment and operating expenses quite minutely, they will not stand the test of a two-fold distribution, made necessary to enable us readily to compute costs. The only way in which I was able to make up my accounts was to list every item of the station and classify the operating expenses practically according to these items. I know that the keeping of all these various accounts of installation and maintenance in such detail requires considerable labor; but I do not know how it is to be avoided, and I should be glad if someone would suggest how otherwise it can be done, because, while bookkeeping is not a pleasant labor, it is an absolute essential.

MR. GOSSLER (Montreal): I have just taken a glance at the subject of this paper, and although I do not know very much about bookkeeping, at the same time I may say that I had a conference with Mr. Cahoon prior to the making of the report to the association last year, and I am of the opinion that the system of accounting presented will permit of great simplification. It seems to me that, to derive the benefits of good bookkeeping, it is absolutely necessary that the system of accounting should be such that the returns for any month will be made in a comparatively short time after the expiration of that month. As I have stated, I am of the opinion that the system of bookkeeping should be simple, and alterations should be made in the suggested systems that will permit of returns being made more promptly than I think is possible under the systems set forth.

THE PRESIDENT: If there is no further discussion on this topic, we will proceed to the papers on the next subject: "Are Loose-Leaf Ledgers Desirable for Electric Companies' Records."

# ARE LOOSE-LEAF LEDGERS DESIRABLE FOR ELECTRIC COMPANIES' RECORDS, AND TO WHAT EXTENT MAY THEY BE ADVANTAGEOUSLY EMPLOYED

G. E. TRIPP

The loose-leaf ledger would not be desirable in the system of accounts adopted by Messrs. Stone and Webster's companies. We use but three different ledgers: the customers' ledger, the general ledger, and the construction ledger.

It would not be of any benefit as a customers' ledger, because we have a new one each year, and this in itself eliminates dead accounts (as I believe this is the principal virtue argued for the loose-leaf ledger).

It would not be required for this purpose for a general ledger, for there never will be any dead accounts in this book, as the number of accounts that can be opened therein is strictly limited. The only advantage, then, of using a loose-leaf ledger for the general ledger would be that of never having a break in an account, viz., that it would always run through consecutive pages; but by the plan of limiting the number and names of the accounts as shown above, we divide the book quite accurately, and the chances of having a break in an account are not of sufficient importance to warrant the extra expense of a loose-leaf book, nor to overcome the general rule that the general ledger of a company should never be in loose-leaf form. Subsidiary ledgers are not so important, as it is possible to test their accuracy by the general ledger and this insures their reliability as an original record. There can be no such test applied to the general ledger; therefore, it would be possible to remove accounts entirely, and the removal could only be ascertained by a checking with the original books of entry. I think it extremely doubtful if the general ledger, which is supposed to collect and combine all other account books of the company, would be as weighty, as evidence before a court, in loose-leaf form as it would in the ordinary firmly-bound book.

These are some of my objections to having the general ledger a loose-leaf ledger.

As to the construction ledger, this is merely a memorandum book containing certain details as to charges to construction. Each account is closed as it is finished, and the dead accounts are of as much value for information as the live ones. Therefore, we do not wish to eliminate the dead accounts.

In view of all the above, I believe my opinion may be summed up as against the use of loose-leaf ledgers.

## H. H. FAIRBANKS

It is rather difficult to explain our system of keeping accounts without seeing it in operation. I have sent samples of our cards, which perhaps will give you some idea of it. I have sent you ten cards of our Consumers' Ledger, which represent ten pages. They are divided, as you will see, in sections of ten, the division card of blue representing the tens and the buff card the hundreds. When a customer drops out we can take out his card and place a new one in its place. We have an index with these cards, giving the page or card on which each customer is located. These cards are fitted in boxes or drawers holding 500 cards, which are fitted into our safe so that they can be cared for the same as our books. When the bookkeeper has occasion to use them he takes the drawers out and places them on a small movable stand by the side of his desk, and then posts his books the same as if it were a regular ledger; and our clerk says he can post to this card ledger a great deal quicker and more easily than he could when we used books.

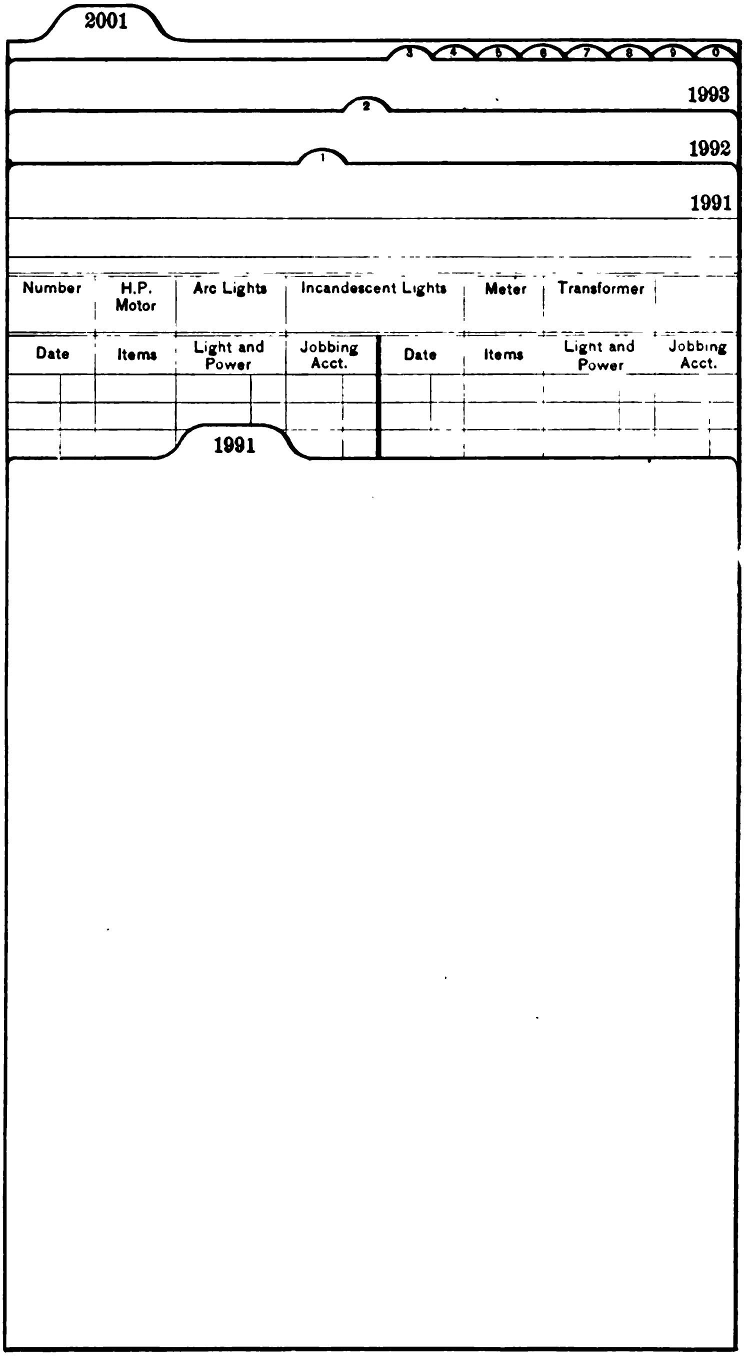
The smaller cards will explain themselves, I think. They are kept in the same manner in the safe, but the division or index card indicates the street on which the customer is located, and as each customer has the street number on his card it makes it an easy matter to locate the card. You will notice that the meter reader's cards have two holes punched at the left; this is for the purpose of inserting them in a pocket cover or case made for them, when the cards are taken out each month to be read.

Our custom in reading meters is to give the reader a certain number of cards representing streets that are in localities near one another, giving him enough cards for a forenoon or afternoon's work. He reports at noon and night and leaves whatever cards he has got the readings for, and then the clerks in the office have them at once to use in making out the bills. This saves an immense amount of time over the old way, when we used books. We can now get our bills all off the first day of the month, as by the time the reader has finished taking the readings the clerks have the bills all made out up to the last half day he is out.

In making out our bills we use an addressograph machine, which also saves us much time. I also inclose copy of our bills. The meter readings are all kept on a book by the streets, so that we can also find the amount each customer has used each month and get the total amount of current used and of the bills. It would be much easier to explain our system if it could be seen in operation. We have found it very convenient and labor-saving.

The cut on the following page shows ten cards, which represent ten pages of our Consumers' Ledger, into which all lights and power are posted. The numbers at the right represent every ten pages of the cards; the small figures at the left represent the last number of the particular division of tens in which it is located. The plain card in front (marked "1991") is a blue card in our boxes, and that at the back (2001) is a buff card. These cards are kept in boxes, fitted into our safe, holding 500 cards or pages each.

If we wish to discontinue a name in the ledger we take out that card and put another in place of it. In connection with these cards we have an index that gives the page or card on which each customer is located.


2001
3
4
5
6
7
8
9
0
1993
2
1992
1
1991
Number
H.P. Motor
Arc Lights
Incandescent Lights
Meter
Transformer
Date
Items
Light and Power
Jobbing Acct.
Date
Items
Light and Power
Jobbing Acct.
1991

.......... .... ........................................................................

...... ............... ............... ....... .......... . ..... ...

| Arc | Inc'd | 8 c p | 10 c p | 16 c p | 20 c p | 24 c p | 32 c p | Total |
|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |

....Transformer..................
...Style........................
....Volts .............. ........
....No. Lights.............. ....
....Number................ ....
....Price Per K. W.......... ....

....Style of Meter ..............
....No. of Meter.................
....Amperes......................
....Volts..... ..................
....Constant.....................
....Meter Reading...............

....Installed by..................... ............. ...........
.. Date of Connection.............................................
.... .. .................... ....................... .........

INCANDESCENT LIGHTS (WHITE CARD), 4 x 6.

No. ..............................................

Constant ............................................

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ○ | ... | .Jan... | .. | .. | .. | .. | .. | .. | 0 | 0 | ... | .Jan... | .. | .. | .. | .. | .. | .. | 0 | 0 |
|  | ... | .Feb... | .. | .. | .. | .. | .. | .. | 0 | 0 | ... | .Feb... | .. | .. | .. | .. | .. | .. | 0 | 0 |
|  | ... | .March | .. | .. | .. | .. | .. | .. | 0 | 0 | ... | .March | .. | .. | .. | .. | .. | .. | 0 | 0 |
|  | ... | .April. | .. | .. | .. | .. | .. | .. | 0 | 0 | ... | .April. | .. | .. | .. | .. | .. | .. | 0 | 0 |
|  | ... | .May.. | .. | .. | .. | .. | .. | .. | 0 | 0 | ... | .May.. | .. | .. | .. | .. | .. | .. | 0 | 0 |
|  | ... | .June.. | .. | .. | .. | .. | .. | .. | 0 | 0 | ... | .June.. | .. | .. | .. | .. | .. | .. | 0 | 0 |
|  | ... | .July.. | .. | .. | .. | .. | .. | .. | 0 | 0 | ... | .July.. | .. | .. | .. | .. | .. | .. | 0 | 0 |
|  | ... | .Aug. . | .. | .. | .. | .. | .. | .. | 0 | 0 | ... | .Aug. . | .. | .. | .. | .. | .. | .. | 0 | 0 |
|  | ... | .Sept.. | .. | .. | .. | .. | .. | .. | 0 | 0 | ... | .Sept.. | .. | .. | .. | .. | .. | .. | 0 | 0 |
| ○ | ... | .Oct... | .. | .. | .. | .. | .. | .. | 0 | 0 | ... | .Oct... | .. | .. | .. | .. | .. | .. | 0 | 0 |
|  | ... | .Nov... | .. | .. | .. | .. | .. | .. | 0 | 0 | ... | .Nov... | .. | .. | .. | .. | .. | .. | 0 | 0 |
|  | ... | .Dec... | .. | .. | .. | .. | .. | .. | 0 | 0 | ... | .Dec... | .. | .. | .. | .. | .. | .. | 0 | 0 |

LIBRARY BUREAU, A853

METER READER'S CARD (WHITE), 4 x 6.

| | |
|---|---|
| ....Price Per Month | ....Style of Meter |
| ....Price Per Year | ....No. of Meter |
| ....Price by Meter.. | ....Amperes |
| ....No. Horse-power | ....Volts. |
| ...Style of Motor | ....Constant |
| | ....Meter Reading |

....Installed by

....Date of Connection

Motor Card (Red), 4 x 6.

| | |
|---|---|
| ..Total Arc Lights | ..Prices per Light |
| ..No. Single Lamps | ..For..........P. M |
| ..No. Double Lamps | .. " All Night |
| ..No. Outside Lamps | .. " All Day |
| ..No. Small Hoods | ..Term of Contract |
| ..No. Cut-out Boxes | ..Date of Contract |
| ..On Circuit No | |

..Date of Connection.

Arc Lights—Series (Buff Card), 4 x 6.

..............................................................................

..............................................................................

| | |
|---|---|
| ....Meter No............ | ...............Report of Test............... |
| ....Volts................ | ............................................ |
| ....Amperes............ | ............................................ |
| ....Constant........... | ............................................ |
| ...Type................ | ............................................ |
| ...Form . ............. | ............................................ |
| ...Maker .............. | ............................................ |
| ........................ | ............................................ |
| ...Date............. .. | ....By.......................................<br>LIBRARY BUREAU, 80710 |

METER TESTING (BUFF CARD), 4 x 6.

....Location..............................................................

Overhead }
....Underground } .Transformer........Lights......No.... ........

| Date | Circuit No. | 8 c p | 10 c p | 16 c p | c p | Arc | Total Lights | Meter |
|---|---|---|---|---|---|---|---|---|
| ...... | ........................ | .... | .... | .... | .... | .... | ...... | ...... |
| ...... | ........................ | .... | .... | .... | .... | .... | ...... | ...... |
| ...... | ........................ | .... | .... | .... | .... | .... | ...... | ...... |
| ...... | ........................ | .... | .... | .... | .... | .... | ...... | ...... |
| ...... | ........................ | .... | .... | .... | .... | .... | ...... | ...... |
| ...... | ........................ | .... | .... | .... | .... | .... | ...... | ...... |
| ...... | ........................ | .... | .... | .... | .... | .... | ...... | ...... |
| ...... | ........................ | .... | .... | .... | .... | .... | ...... | ...... |
| ...... | ........................ | .... | .... | .... | .... | .... | ...... | ...... |
| ...... | ........................ | .... | .... | .... | .... | .... | ...... | ...... |
| ...... | ........................<br>LIBRARY BUREAU, A91204 | .... | .... | .... | .... | .... | ...... | ...... |

——— (WHITE CARD), 4 x 6.

All Bills are due the first of the month, and must be paid before the 10th of the month to avoid shutting off the current.

..............................

## To The Worcester Electric Light Company, Dr.

....For use of Arc Electric Lights for the Month of..............................

| | | |
|---|---|---|
| ....Lights .. ....nights at .......cents each per night............. | ........ | ...... |
| ....Lights........nights at........cents each per night............... | ........ | ...... |
| ....Lights... ....nights at........cents. each per night............... | ........ | ...... |
| ....Lights........nights at....... cents each per night...... ........ | ........ | ...... |
| .............................................................. | ........ | ...... |
| .............................................................. | ........ | ...... |
| .............................................................. | ........ | ...... |
| ..............................................Total ...... | ........ | ...... |

... ..........Received Payment for the Company..............................

....Worcester......... .............190.... ..............................

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## Worcester Electric Light Co.

..............................

### COLLECTION COUPON.

..For Bill..............................

| | | |
|---|---|---|
| ..For Arc Lights ......... | ........ | .... |
| .......................... | ........ | ...... |
| ..For Power............... | ........ | ...... |
| .......................... | ........ | .... |
| ..For Jobbing Acc't....... | ........ | ...... |
| .......................... | ........ | ...... |
| .......................... | ........ | ...... |
| ................Total.... | ........ | ...... |

To be Detached from this Bill.

When Paid....................190....

ARC LIGHT BILL.

All Bills are due the first of the month, and must be paid before the 10th of the month to avoid shutting off the current.

## To The Worcester Electric Light Company, Dr.

For Electric Current Supplied in the Month of ....................

Present Meter Reading .......... .00
Last Meter Reading .......... .00
Constant .......... .00
Total K. W. .......... at ....c. per K. W.
Total ..........

Received Payment for the Company ..........

Worcester .......... 190 ..........

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## Worcester Electric Light Co.

### COLLECTION COUPON.

For Bill. ..........

For Incandescent Lights. ..........
For Arc Lights ..........
For Power. ..........
For Jobbing Acc't. ..........
Total ..........

To be Detached from this Bill.

When Paid .......... 190....

INCANDESCENT LIGHT BILL.

All Bills are due the first of the month, and must be paid before the 10th of the month to avoid shutting off the current.

## To The Worcester Electric Light Company, Dr.

For Electric Current Supplied in the Month of ....................

Present Meter Reading .................... .00

Last Meter Reading .................... .00

Constant .................... .00

Total K. W. .................... at ..... c. per K. W.

Total ......

Received Payment for the Company ....................

Worcester .................... 190 ....

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## Worcester Electric Light Co.

### COLLECTION COUPON.

For Bill ....................

For Power. ....................

For Arc Lights ....................

For Incandescent Lights. ....................

For Jobbing Acc't. ....................

Total ......

To be Detached from this Bill.

When Paid .................... 190....

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Power Bill.

## GEORGE W. DAVENPORT

I have read with great interest the arguments of Mr. Tripp and Mr. Fairbanks.

It seems to me that the term "loose-leaf ledger" has been rather loosely used by Mr. Tripp and Mr. Fairbanks; the one speaking, I think, of a loose-leaved book of the type manufactured by the Baker-Vawter Company—and other companies—the other of the card ledger.

It seems to me that any system which requires that the names of customers be wholly rewritten at frequent intervals is open to objection. In a small company (and by this I mean a company of less, we will say, than one thousand customers) a form of loose-leaf ledger with separate leaves devoted to each letter of the alphabet, can be used to good advantage. Above one thousand customers I do not believe in any form of *book*, and am firmly of the opinion that Mr. Fairbanks' plan, or some other on the same lines, is the correct one.

With a company having about 2,500 customers I used a card ledger with excellent results. We used a meter-reading card, which was carried by the meter reader, arranged in routes, and afterwards assorted numerically to conform to the customers' number of accounts,—very successfully. The customers' ledger card was of considerable size the long way of the card up and down, and contained space enough for three years' business. These cards were removed from the cases when the customers left town in the spring and restored on their return in the fall, provided, of course, the current was shut off. The customers' ledger card, however, bore only the financial information required; the details of the meter reading and other charges were made on an intermediate card between the meter card and the ledger. This enabled two clerks to work ; the one transferring statistics from the "meter card" to the "statistic card" and the other making charges from the "statistic card" to the "ledger card."

Credits from the ledger card were made from the stub of the bill, which was put on a spindle by the cashier when the money was received. This enabled the treasurer to make one entry each day on his cash card, crediting "Customers' Accounts Receivable," and the ledger man made his credits of the ledger cards from the slips, which were afterward filed away in a wrapper indorsed with the amount of the day's collections. This worked admirably, accurately and quickly, beside being very flexible, permitting of a number of clerks working upon any particular branch of the work that required special attention, as, for example, the making out of bills from the ledger cards at the end of the month.

## CHARLES R. PRICE

Some years since, while trying to devise some way to shorten work in the accounting department in order to save making an addition to our office help, the attention of the writer was called to the advantages of a loose-leaf ledger.

Our company sells gas, electric light and power of all kinds, gas stoves and appliances, gas and electric fixtures, besides doing a large business in gas piping and electric wiring, so our bookkeeping is somewhat varied in character. We have about forty-five hundred gas and a thousand or more electric customers; the accounts of the former arranged as to streets and those of the latter in alphabetical order, with separate ledgers for each. Although in the past all of these have been rewritten each year—and this work must be done in addition to the regular daily duties—we have not yet been able to see that there would be saving enough to warrant our adoption of the loose-leaf ledger system in either our "Corporation" or "Sales" sets of books. In the former our long and continuing accounts are too few, and in the latter we have too many small and sundry accounts.

Our practice has been to rewrite and rearrange our consumers' lists each year, though I think we shall try to make the present sets run two years. I do not believe a longer time is practicable, owing to changes in streets, houses, tenants and moving, in a growing city. A longer period would not be consistent with clearness and neatness in results.

The Cambridge Gas Light Company of Massachusetts has adopted a card ledger system over which the treasurer is very enthusiastic, as these may be written up with the addressograph. This, besides giving quick and neat work, enables changes of routes and postings from route books to be made rapidly, and may give several years' records of each customer. The system seems to have several excellent points, but it was a debatable question whether cash postings from bill stubs could be made as rapidly, or the footings of monthly lists obtained or lists of non-paid accounts be drawn off as quickly, as from a bound book. There is also the possibility of the abstraction of an account.

The addressograph is now so made as to print on the left side of the page of a book or sheet, which will greatly extend the usefulness of this excellent office assistant and remove one argument in favor of the loose-leaf system; it should be made, however, so as to print from above, so that the work may be seen as printed.

While we do not see the advantages of a loose-leaf ledger to the extent of adopting it, we have devised a loose-leaf sales journal, which we find facilitates getting out our monthly work in a way much appreciated by the bookkeepers. These are printed forms of uniform size, on different colored sheets for our different departments, showing the usual material and labor charged on jobs for wiring, piping, or shop accounts, fixtures, etc. They are usually filled in by the workman as to items, price filled in by the foreman, and when numbered and bound in ready-made covers, form an original day book. Each sheet has all the information regarding any particular job, and is good evidence if a legal question ever arises. The last sheets of each month have a recapitulation of the total work under each heading for the month, and are posted into the sales ledger, from which a simple journal entry carries the monthly work into what we call our "Corporation Set." All bills are made from the journal sheets so that the work is transcribed but once in the office, and with from three hundred to six hundred bills per month, of varying lengths, this is a very considerable item of labor saved.

From the above review of our system of work, I do not at present see any advantages in a change to a loose-leaf method of keeping the accounts of our company.

## DISCUSSION

THE PRESIDENT: These papers illustrate, perhaps better than anything else, the programme idea we have attempted to follow in this convention; that is, to obtain the views of different men on certain subjects in short and concise form. Are there any comments?

Mr. Smith (Somerville, Mass.): Mr. Fairbanks, in reading his paper, described substantially a system that we use in our company. We used to have in our consumers' accounts a regular consumers' ledger, which had short leaves and would carry the accounts for two years; but, beginning with the first of this year, we have used a system of cards similar to that he has described, and we find it a great improvement. Our cards are so printed as to carry the accounts for four years. I understand from Mr. Fairbanks' sketch that his card does not give the date when a bill is paid. Our cards give the date of each month, printed on the left-hand side. The meter readings are given on this card, the amount of the bill, and when it is paid. There is a large saving in time in posting the accounts and keeping them straight through the system of numbers that we have adopted. In the beginning, we sort the cards according to the routes, and as customers drop out we can remove the cards, and, as new customers come in, put in new cards and interpolate the numbers. If we have a customer numbered 150, his next-door neighbor coming in would be between 150 and 151; we could put it 150.1 or 150.5; and if another party came in afterward his number could be 150.3. Our meters are kept in the same way, so that we can take the cards out of the file in the easiest manner to get at the customer. They are always arranged according to routes. I should not adopt the card system of ledgers for our general accounts. We use it for our consumers' accounts and petty ledgers, but could not recommend it for the general corporation accounts.

Mr. Price (New Bedford, Mass.): Since I wrote this paper I have had an opportunity to investigate Mr. Barnes' system at Cambridgeport, and I think that, on the whole, there are many advantages in keeping customers' accounts on cards or small sheets, as adopted by him. He has one practice that overcomes the objection that occurred to me at first, and that is in his cash-sheet system. His cash book, instead of being a bound book, is used as cash sheets, carefully numbered and divided so that three or four clerks can work on the cash returns at the same time. The posting is done by small rubber stamps, by which he checks off the returns and posts them at the same time. The posting can be done more rapidly in this way than with a book, with the advantage that the work can be continuous; whereas, in the case of using a book, only one person can use the book and card at the same time. I believe that anyone who will investigate the card system will find that there are more advantages to it than appear at first sight.

THE PRESIDENT: I might add that this subject was very fully discussed at a meeting of the Ohio Gas Light Association. Their methods of accounting would not differ greatly from ours. I happen to be a believer in the loose-leaf ledger form of keeping accounts. You can make it so absolutely perfect that there is no chance of a sheet being abstracted without your knowing it. You issue sheets numbered in consecutive order and signed by some person who can be held responsible for them. If anyone cares to look up this subject, you will find that four contributions were read at the meeting of the Ohio Gas Light Association held last March. We had already planned to have this subject on our programme, and we did not think it wise to lay it aside; but you will find in the report of the Ohio Gas Light meeting much data that has not been presented here. If there are no more comments on this subject, we will take up the consideration of some of the questions assigned for this evening.

(The following questions were then taken up and discussed, for which see Question Box: Nos. 6, 50, 54, 56, 59, 62, 63, and 66.)

(The meeting then adjourned.)

# ORDER OF BUSINESS

WEDNESDAY, May 21st, 1902.

### FOURTH SESSION, 10 A. M.

1. Question Box
2. Discussion—"Three-Phase *versus* Two-Phase for City Distribution." B. A. BEHREND, CHARLES F. SCOTT
3. Question Box
4. Report—Committee on Rules for Electrical Construction and Operation. CAPTAIN WILLIAM BROPHY, Chairman

### FIFTH SESSION, 2.10 P. M.

1. Question Box
2. Report—Committee on Photometric Values of Arc Lamps. HENRY L. DOHERTY, Chairman
3. Topic—"Protection of Long-Distance Transmission Lines." CHARLES H. BAKER, L. DENIS, P. N. NUNN, HENRY J. GILLE, P. M. LINCOLN, NORMAN T. WILCOX, P. G. GOSSLER, F. A. C. PERRINE

### SIXTH SESSION, 8 P. M.

1. Executive Session
2. Paper—"Display Lighting, Signs and Decorations." By RUSSELL SPAULDING
3. Paper—"Possibilities of Sign and Decorative Lighting." By E. J. MCALLISTER

# FOURTH SESSION

President Doherty called the meeting to order at ten o'clock, and questions Nos. 33, 34 and 35 were taken up and the answers read (for which see Question Box), but there was no oral discussion. The next order of business was the papers on "Three-Phase *versus* Two-Phase for City Distribution," by Messrs. B. A. Behrend, of Cincinnati, and Charles F. Scott, of Pittsburg.

# THREE-PHASE VS. TWO-PHASE FOR CITY DISTRIBUTION

B. A. BEHREND

The question whether or not the three-phase current is superior to the two-phase current for the distribution of light and power in cities, has been argued for the past eight years. At first, there were a great many advocates of the two-phase current, on account of the greater simplicity of this system. Looking to-day over the installations of alternating-current systems for city distribution, we find the fact established that the three-phase distribution has been preferred to the two-phase distribution in the majority of plants.

That system will be most favorable for distribution of light and power in which the potential on one phase is as little as possible affected by a change of load on another phase. This may be considered the criterion by which to form an opinion of the superiority of one system over another.

At first sight, it would seem that the two phases in a two-phase generator, being in quadrature with each other, would not be subjected to mutual induction. We must consider, however, that the two armatures of a two-phase machine, although displaced toward one another by ninety electrical degrees, and, so far as this displacement is concerned, being independent of one another,—are electro-magnetically connected with each other through the revolving field.

We therefore find that the two phases in a two-phase machine are *not* independent of one another; that is, a load on one phase affects the potential on the other.

Theoretical considerations, as well as experience, have established the fact that a two-phase machine, so far as independence of phases is concerned, is not superior to a three-phase machine if the load on the latter is properly arranged.

The output of a two-phase generator is equal to the output of a three-phase generator. In other words, any two-phase generator may be wound as a three-phase generator without changing the rating, and *vice versa.*

The regulation of both two-phase and three-phase machines being equally good, according to the statements above made, it would seem that the three-phase system was preferable to the two-phase on account of requiring only three wires instead of four, leaving out of consideration the two-phase, three-wire system. There is, however, a very interesting fact which should be observed, namely, a three-phase generator on which the load is connected between the outside wires, is greatly inferior to a two-phase so far as regulation is concerned. Only, if the neutral connection of the three-phase generator is made use of, and if the load is put on between the neutral and the outside wires, the regulation in the three-phase machine is, in all respects, equal to that of the two-phase machine. But it must be observed that the three-phase machine requires, under these conditions, four wires, as well as two-phase machine.

Summing up the pros and cons, we may state that there is comparatively little choice between the two-phase and the three-phase systems, but there are certain slight advantages in favor of the three-phase system. If seventy-five per cent of the load is a lighting load and twenty-five per cent is a load that requires little attention to regulation, as, for instance, an arc-light load having its own regulator, or a motor-load, a three-phase generator has the further advantage that it can be operated as a single-phase machine, the lighting load being connected between two outside wires. In this case, the lighting load can be very easily regulated, while no attention need be paid to arc-light or motor load, as that is supposed to take care of itself.

### CHARLES F. SCOTT

It is a significant fact that, as the result of the evolution which has taken place during the last dozen years in electrical systems for general city distribution, the type of generator that is most widely used is the polyphase alternator. This is the case whether the current is to be used ultimately as polyphase alternating current, as single-phase alternating current, or as direct current, either for incandescent or arc lighting, for stationary motors or for street-railway service. It has not been an unusual thing to find stations in which small engines drive series-arc machines for arc lighting; other engines drive direct-current generators for 220-volt, three-wire lighting and power; other engines drive 500-volt, direct-current generators for railway service or stationary power, and still other engines drive alternators for furnishing light and power to outlying districts. In the modern station all these different kinds of electrical activity are operated from large economical engines driving polyphase alternators.

While there is practical unity of opinion that the generator should be a polyphase alternator, yet the conditions which determine whether a given alternator should preferably be of the two-phase or of the three-phase type are not fully understood. The question is one that has at times aroused a considerable interest, and in the discussion which has taken place upon the subject the ardor of the advocates has sometimes exceeded their technical knowledge of the subject. In fact, it is quite likely that a good deal of the discussion has been on a par with that which is related to have taken place before a certain village council where the merits and shortcomings of various electrical systems were definitely set forth by various agents who were ready to close contracts. The superior merits of the "quarter-phase" system had been eloquently and convincingly presented, and there was apparently no field remaining for anything else. The next gentleman, however, undaunted by what had preceded him, expatiated upon the superiority of the "two-phase" system, explaining its superior merits and how far it surpassed the claims of that which was merely quarter-phase, and he was, withal, so clear and convincing that he won over the city fathers and secured the contract. He was, however, a little more convincing to others than to himself, for he immediately inquired of a friend to know just wherein lay the difference between the two-phase and quarter-phase systems, as there was something there that he did not quite understand himself.

There seems to have existed in the minds of many a conviction that one or another so-called "system" possessed superior and peculiar excellence. We may discard any ideas of mysterious merit of the kind that prevails in patent-medicine literature. The choice between the two-phase and the three-phase systems should he made along other lines than those which have just been indicated. It is presumable, also, that the complete answer to the query will not be in favor of either one to the exclusion of the other, but, as in most engineering problems, it will be found that each side has its own characteristic qualities, which adapt it better for some cases than the other. Each has its own advantages. Sometimes the conditions are such as to dictate clearly which is to be preferred; in other cases they are fairly well balanced, so that it is difficult to decide just which is best, and in such cases no great mistake can be made if either be chosen.

The meaning of the terms single-phase, two-phase and three-phase is well known. A simple illustration may be cited which shows the relation between the several arrangements. If two exactly similar armatures for delivering single-phase current be placed with their windings exactly in line upon a common shaft, and if these armatures be surrounded by similar fields that are not in line, but have the poles of one field placed in an angular position midway between the poles of the other field, then the single-phase current which is delivered by the second armature alone does not correspond in its time or phase relation with that of the first armature, but the maximum value of this electromotive force will occur midway between the maximum electromotive forces of the first armature. The two single-phase currents, considered together, are suitable for supplying a two-phase system. If instead of two armatures and fields there are three, with the armatures in line and the fields displaced so that the angular interval between field poles is one-third instead of one-half of the pitch angle between two poles, then the three currents having their maximum values at equal intervals are suitable for supplying a three-phase system. An analogy between the single-phase, two-phase and three-phase currents is found in the single, double and triple-crank engines.

The choice between two-phase and three-phase is not dependent so much upon their abstract and theoretical characteristics as it is upon the actual differences in the characteristics of two-phase and three-phase apparatus, which may exist in the generators, the transformers, the motors and in other apparatus. For example, with certain types of generators there may not be the same reason for choosing one number of phases that there may be with another type. On the other hand, as current may be used in one way in one place and in another way in another place, it may be best to select two-phase generators in one case and three-phase generators in the other case, although the two generators may otherwise have substantially the same characteristics. The problem, then, is to determine what differences there are in apparatus, and in its operation under different conditions, between the two-phase system and the three-phase system, and to determine which, on the whole, is preferable under given conditions.

Polyphase load—as distinguished from single-phase load—is quite indifferent as to whether the current be two-phase or three-phase. That is to say, alternating-current motors, whether induction or synchronous, and rotary converters may be constructed for two-phase or for three-phase without any appreciable difference in either the cost or the performance of the machines. Likewise, alternators which supply current to motors and rotary converters, in which case each phase is equally and similarly loaded, may be wound for either two-phase or three-phase without any appreciable difference either in cost or in performance. It follows, therefore, that when polyphase alternators supply current to polyphase apparatus, any choice that there may be between two phases and three phases must be based upon features that lie outside of the machinery.

The transmission circuit is the important additional element. It is well known that with a given maximum electromotive force between wires a given power can be transmitted over three wires by three-phase current with the same loss that occurs with four wires when two-phase current is employed. The three-phase current, therefore, effects a saving of one wire or 25 per cent over two-phase. The relative importance of this saving depends upon circumstances; if the distance be long, it is considerable; if the distance be short, it may be a matter of relative insignificance.

The transformers that may be required between apparatus and transmission circuit in certain ways favor two phases and in other ways three phases. The two transformers for a two-phase circuit are obviously of less cost per kilowatt and of higher efficiency and closer regulation than the three transformers of lesser size which would usually be used for the same aggregate output on a three-phase circuit. It is true that two transformers on two phases of a three-phase circuit may be used, but, besides the objection to an unsymmetrical or an unbalanced arrangement, there is less effective operation of the transformers.

For supplying current to a three-phase motor or rotary converter by two tranformers connected on two of the phases, it is necessary that the normal output of the transformers should be increased by approximately 17 per cent above what would otherwise be required, due to the fact that the two transformers do not operate efficiently for delivering current to the third phase. For example, if 600 kilowatts were to be delivered, three 200-kw transformers, one on each phase, would be the ordinary arrangement. If only two transformers were used, 300 kilowatts each would be the required output if the transformers operated effectively, but when they are connected on two of the phases the size should be increased by 17 per cent, making about 350 kilowatts. In other words, each of the two transformers for supplying one-half of 600 kilowatts, when connected to two of the phases of a three-phase circuit, has currents flowing in its coils that are equal to those which would flow if the transformer delivered 350 kilowatts to a single-phase circuit. It may be observed that if three transformers, each of 200 kilowatts, one on each phase, are arranged for normally delivering 600 kilowatts, and if one of the transformers is out of service, the other two can deliver power to a three-phase circuit, although the output will be reduced to less than 400 kilowatts, namely, about 350 kilowatts, or 60 per cent of the output of the three transformers. These transformer relations are not of very great importance and in general do not determine the choice between one system or the other.

Switches and switchboard instruments differ slightly for two-phase and for three-phase circuits. In one case switches for four wires are required and in the other case switches for three wires are usually sufficient; although when the three transformers on a three-phase circuit are to be cut out individually, each transformer requires a double-pole switch, so that six instead of three wires require switches.

Measuring instruments are usually simpler and more straightforward in their indications on a two-phase circuit than on a three-phase circuit. The readings of current and power on a two-phase circuit consisting of two parts which are fairly independent of one another, are much to be preferred, particularly for those who are not skilled in the theory of alternating-current measurements.

In conclusion, therefore, when polyphase load—such as motors or rotary converters—is to be served, the most important item in making a choice between the two systems lies in the transmission circuit; and the saving of conductors by the use of the three-phase system renders its selection advisable in most cases.

Single-phase load—such as is common with incandescent lighting and arc lighting—involves considerations that do not apply to polyphase loads. When the several circuits from a polyphase alternator supply independent single-phase circuits, these circuits are liable to be unequally loaded. The effect of unequal loads upon the several phases is that the voltages on the different phases will differ. In general, the single-phase circuits are used for lighting, in which it is particularly desirable that constant voltage should be maintained.

The voltage on a single-phase machine may be controlled and properly adjusted by means of a rheostat in the field circuit of an alternator. In the same way the voltage of a polyphase alternator may be raised or lowered, but changes in the field obviously do not afford a means of independent adjustment of the voltage on the several phases or circuits of the armature. Variations in the field current will produce corresponding variations in the voltage on all of the circuits. For this reason it is important that unequal load on the several circuits should produce as small a difference in voltage as is possible.

In a two-phase alternator the voltage on each phase is nearly independent of the load on the other phase. Consequently, a change in load on one phase has but little effect upon the voltage of the other phase. In a three-phase alternator, on the other hand, load on one phase does affect the voltage on the other phases. One of the peculiarities of this interrelation is that a change of load on one phase acts differently on the voltages of the other two phases, usually raising one and lowering the other. Again, when one phase is not loaded and two of the phases are equally loaded, the voltages on the latter are not equal, but may differ considerably. A change in the load of one phase generally affects the voltage of each of the other phases, and affects them unequally.

The importance of the foregoing considerations depends to a large extent upon the regulation characteristics of the alternator itself. The percentage by which the voltage of an alternator increases when load is thrown off (the speed and field excitation remaining constant) is termed its inherent regulation. The closer the inherent regulation of an alternator, the less is the difference in voltage between the several phases when they are unequally loaded. It follows, therefore, that close inherent regulation is particularly desirable where unbalanced loads are likely to occur. An alternator of very poor inherent regulation, which might suffer a change in voltage of 20 or 30 per cent when load is removed, may be compensated by auxiliary external means for adjusting the field current so that the voltage will be constant for small loads and for heavy loads. It is necessary, however, that the several circuits from such a polyphase alternator be equally loaded, and it is impossible by any kind of field regulation to secure equal voltages when the circuits are unequally loaded. This type of machine, therefore, is one that is not at all suited to the independent loading of the several circuits, such as is common in stations that have single-phase circuits for incandescent and arc lighting. It may be remarked, also, that machines of this type are quite inferior, even for polyphase work, in service where the loads are subject to rapid fluctuations, as machines of this type are not apt to regulate quickly. Machines of very poor inherent regulation, moreover, are not to be recommended for supplying current to rotary converters, as in some cases rotary converters will hunt and will not operate satisfactorily when supplied with current from generators of this class; whereas they will operate satisfactorily from generators having close inherent regulation.

Unbalanced load is therefore a much more serious matter with generators of poor inherent regulation than it is with generators of good inherent regulation, and it is desirable, in selecting machines, to choose those which have good inherent regulation. When this is obtained there is less reason for preferring a two-phase machine instead of a three-phase machine than there is in those cases where the inherent regulation is not so good. The inherent regulation of small alternators is not so good as that of large alternators. Alternators of a 100-kw output do not in general have as good inherent regulation as those of a 1,000-kw output. It follows, therefore, that stations employing large generators may be able without great inconvenience to use three-phase generators, although smaller stations could be operated to better advantage with two-phase generators for the unbalanced loads which they may have to accommodate.

The division of a number of single-phase circuits between the two phases of a two-phase generator is more readily and simply accomplished than the division among the three phases of a three-phase generator. This is a matter of some importance, particularly in connection with small stations.

Single-phase lighting circuits may be operated from one phase only of polyphase alternators. The other phases may remain idle, or may supply other kinds of load where exact regulation is not of great importance, such, for example, as arc lighting; or all the phases of the alternator may supply current to polyphase load. Under these conditions the field current may be adjusted to give the proper voltage on one of the phases without respect to other voltages.

When one phase only of a polyphase alternator is loaded, the output is less than when all phases carry an equal portion of the load. The load that may be carried on one phase is dependent in most cases upon the temperature. If the heat in an armature coil is confined by the insulation so that it is not readily conducted away, then the current permissible in this coil is not dependent upon the current in other coils. Therefore, no coil on an armature of this kind should carry more current when other coils are idle than it does when all coils carry their normal current. On the other hand, if the heat in the coils on an armature is readily communicated to the armature, so that the temperature of a coil is determined by the total heat in the armature rather than by that in the coil itself, then it is permissible to have more than the normal current in such a coil when other coils are idle. There are, therefore, two different methods of determining the heating in a polyphase armature with single-phase load, which apply to different types of machines. Actual armatures will be found to lie between these limits, some approximating one limit and some the other limit.

The output of polyphase armatures when delivering current on one phase only as compared with the normal polyphase output when all the circuits are equally loaded, determined under the condition that no coil carries more than its normal current, is as follows:

| | |
|---|---|
| Three-phase, closed-coil winding (delta) | 50 per cent |
| Three-phase, open-coil winding (star) | 58 per cent |
| Two-phase, open-coil winding | 50 per cent |
| Two-phase, closed-coil winding | 71 per cent |

In the closed-coil windings of both the three-phase and the two-phase armatures, all of the coils carry current when single-phase current is delivered, whereas, in the open-coil armatures a part of the coils are idle when single-phase current is delivered.

The output of polyphase armatures when delivering current on one phase only, as compared with the normal polyphase output when all circuits are equally loaded, determined under the condition that the total heating in the armature conductors is the same in both cases, is as follows:

| | |
|---|---|
| Three-phase, closed or open-coil winding | 71 per cent |
| Two-phase, open or closed-coil winding | 71 per cent |

When one phase only is in action, and, consequently, also when there is considerable unbalance between loads on the several phases, the above relations show that when the same maximum heating in individual coils is taken as a basis for comparison, the two-phase, closed-coil winding possesses marked superiority over the others.

When the total heat produced in the armature windings is considered, the several types of winding are found to be on a par, although the two-phase, closed-coil winding still possesses an advantage in that the heating is equally distributed through all the windings, while in the other cases some of the coils are entirely idle, or carry only a small current, while other parts of the winding carry more than their normal current.

The transmission circuit must also be considered when unbalanced loads are to be carried by a polyphase generator. The circuits from a two-phase generator may be run independently of one another, having separate wires without mutual induction between the circuits. A greater or less current in one circuit does not directly affect the voltage of a second circuit. The three circuits from a three-phase generator likewise do not affect one another, provided each circuit has its own separate conductors, so that with three feeders, one from each of the three phases, each has its own two wires, thereby making six wires in all, and effecting no saving in copper over two feeders. On the other hand, in the three-phase, three-wire circuit the current flowing to the load on each phase affects the voltage in each of the three phases. As the several phases use common wires, the ohmic drop caused by the current in one circuit affects the voltage in the other circuits. Moreover, the current in each pair of wires acts as a primary current which sets up a secondary electromotive force in each of the other pairs of wires. Current flowing in wires *A* and *B* of a three-phase circuit induces electromotive forces in circuits *B* and *C* and also in *C* and *A*. In a two-phase, four-wire system, the two phases may be separated or one circuit may be transposed so that no electromotive force is induced in one from the other. Such an arrangement is obviously impossible in the three-phase, three-wire circuit, as the wires are common to the several circuits. The magnetic field set up by current in one pair of wires must necessarily pass through the area between each of these wires and the third wire, thereby causing electromotive forces to be induced. The electromotive forces which are induced in the other two phases are not equal in effect. In one circuit, the voltage is usually increased, and in the other circuit it is diminished, thereby tending to inequality and unbalance.

The consequence of this close inter-relation between phases is that a change of load on one phase affects the drop in each of the other phases, and by unequal amounts. For this reason, very great precautions are sometimes taken to avoid unbalanced load. The three wires of the three-phase circuit are carried throughout the whole system, and incandescent lamps are grouped in threes, one on each phase.

Feeder regulators, consisting usually of transformers of variable ratio, by which the voltage may be raised or lowered, are in general use. Such a regulator on a single-phase feeder from a two-phase or a three-phase alternator may raise or lower the voltage of that feeder without affecting the voltage on other feeders. On a three-phase, three-wire feeder, however, a regulator in one phase does not limit its action to that phase only, but affects one or both of the other phases. If such a feeder has regulators in each of the three phases, it is obvious that skillful manipulation of the try, try again kind is necessary to obtain proper voltages on each of the phases on which the loads are independently varying, as a change of any regulator affects more than one voltage.

The regulation of a group of three transformers, connected either in delta or in star, is in a measure similar to that of a three-phase line, as the drop in voltage in the secondary of each phase is dependent upon the current in the other phases as well as in itself.

It is this intimate inter-relation between phases, and the somewhat erratic changes in voltage on all phases when current changes in one phase due to inter-relation in generator, in circuits and in transformers, which constitutes the principal reason for preferring two phases where single-phase lighting is to be operated.

The transformation from two-phase to three-phase and vice versa by a main and a teaser transformer, is interesting to consider in relation to regulation. If two-phase circuits are supplied from transformers, there is substantially the same independence between phases whether the alternator and transmission circuit be two-phase or three-phase. That is to say, a three-phase alternator and a three-phase line regulate as a two-phase generator and a two-phase line if the load be on two-phase circuits. The advantages of three phases may therefore be secured in transmission, while two phases are employed in distribution. In some long-distance transmission plants the three-phase current is used as three-phase current for polyphase power, such as rotary converters, and is transformed to two-phase current for lighting distribution.

The importance which attaches to the unbalance of voltage between different phases and the effect of load upon one phase upon the voltage on other phases, is obviously dependent upon the difference in voltage that will be produced under operating conditions. This in turn depends quite largely upon the size and output of generator. The closer the inherent regulation of the generator, the less will be the unbalanced condition. Again, the difference in voltage depends upon the amount of unbalanced load. If the conditions are such that the amount of unbalanced load is relatively small, or if a good proportion of the load is polyphase load which will be balanced, then the difference in voltage will be small. It is further to be noted that polyphase motors and rotary converters have an inherent tendency to equalize the voltages of the several phases. As generators of small size have relatively poor inherent regulation, it is desirable that when such machines are to be used for supplying single-phase lighting circuits they be made of the two-phase type. Attention has already been called to the fact that if single-phase circuits are run from the several phases of a three-phase machine instead of employing three-wire circuits, there is no gain in copper in the transmission circuits over what would be secured if single-phase or two-phase generators were used.

A further matter has not yet been given consideration. It is the method of running secondary circuits for serving both light and power. Circuits of this kind will in general be operated from larger plants. In small towns the service is usually distributed directly from transformers without secondary mains, and in general separate transformers are supplied with motors.

There are several arrangements of three-phase and of two-phase circuits, either of which may be used for secondary distribution. For lighting alone it is probable that the single-phase, three-wire circuit giving approximately 110 and 220 volts is the simplest and most acceptable. For the motor service a three-phase, three-wire circuit would be the simplest.

In one large plant which uses secondary mains the current is wholly two-phase. Lighting is done on one phase of a secondary circuit, this phase having three wires giving 220 volts across the outside wires and 110 volts between the middle wire and the outside wires. Two outside wires supply current to one phase of induction motors, and the other phase is obtained from one of the same wires and an additional or fourth wire. The motors are, therefore, operated on a two-phase, three-wire circuit. This type of circuit has some disadvantages, but on the whole this method has been found quite satisfactory. This arrangement approximates the circuits above proposed, *i. e.*, 110 and 220 volts single-phase for operating lights and a three-wire circuit for operating motors, the latter circuit being two-phase instead of three-phase.

In another two-phase plant each of the two phases has three wires, and the middle wire in the two phases is common. There are, therefore, five wires, one of which is a common neutral to the two phases, and the voltage between it and each of the other wires is 110. Either of two three-wire, single-phase circuits is therefore available for lighting, and the four outside wires are available for the operation of two-phase motors.

Three-phase secondary circuits may be operated at 220 volts, with a neutral wire which differs in voltage from each of the others, being approximately 125. Motors may be connected to the three main wires and lights between the neutral and other wires.

Other arrangements of secondary circuits for combining light and power may be used. In general, each has characteristics which render it well suited for some conditions and not well adapted to others. There is no single plan which is a specific for all conditions. In general it is for the engineer, after a careful consideration of the characteristics of the apparatus and the requirements of the service, to determine what is best adapted to meet the conditions in the different cases which arise.

## DISCUSSION

THE PRESIDENT: Are there any questions or comments on these papers?

MR. BEHREND: Mr. President and gentlemen: I can not refrain from expressing my appreciation of the views that Mr. Scott has laid before you. I feel especially gratified that the views presented by so high an authority should so closely coincide with my own ideas on the subject. As my paper was very short, I will take the opportunity of commenting on a few points that Mr. Scott brought out in his paper. I find that Mr. Scott agrees with me that small machines should be single-phase; larger machines, two-phase, and still larger machines, three-phase. As regards three-phase machines, I wish to emphasize a point which, perhaps, I did not bring out clearly enough. By a three-phase distribution, I have always understood a three-phase, four-wire system; of course, only for lighting distribution. There is one point that I think might be of general interest to you gentlemen here, and that is the question of margins in generators and the question of inherent regulation. We designers of alternating current know that the question of regulation determines not only the design of the machine, but also the cost of the machine. In the specifications that we receive for generators, it often happens that a regulation is specified in a manner that it is next to impossible to check up by experiment. For instance, if you build a generator like the one being installed here by my company—a unit of 3,000 kilowatts, 60 cycles, 4,000 volts—it is extremely difficult, if not impossible, to make a full-load test on a non-inductive resistance. You can not obtain a non-inductive resistance large enough to dissipate 3,000 kilowatts, therefore you can not get accurate measurements. You have to fall back on a water resistance, which is unreliable on account of the polarization, which acts like a capacity, and therefore your voltage drop comes out smaller than it actually is; and such a test is apt to deceive anyone who is not perfectly familar with alternating-current work. The question then arises, how can a customer protect himself against getting machines that do not comply, as regards regulation, with the specifications he has sent out? I should say that any specifications should specify, not only the volts in per cent—that is, not only the rise in voltage—but should also specify the short-circuit current of the generator for full normal excitation or for normal no-load. The short-circuit current is the better check; although I do not wish to say that it is a perfect check; but it is better than anything else for the determination of your voltage drop and regulation. There are some interesting illustrations of what I have said, which may be of interest to you. When you go to New York, if you visit the grand stations that have been installed by the General Electric Company and the Westinghouse Company, you will be able to make some interesting comparisons. The generators of the Metropolitan Street Railway Company are rated at 3,500 kilowatts, at 75 revolutions. The generators have an overload capacity of 1,000 kilowatts, according to Mr. Steinmetz's statement, and you might consider them 4,500-kw generators working on a system of synchronous converters. There is another plant in course of construction, several units of which have been installed, certainly the grandest station in the whole world; the station being built by the Westinghouse Company for the Manhattan Railway Company. The units are rated from 5,000 kilowatts up to 7,500, and any visitor to the New York stations, who sees these plants, will draw a parallel between the generators in the two plants, viz.: the tremendously large Westinghouse generators and the small General Electric generators. The reason for the different sizes of the two machines is that the Westinghouse generators have close regulation and the General Electric have not. This may not be a fault in the General Electric generators, as I do not agree with Mr. Scott that close regulation is absolutely essential; but if you have a load of rotary converters that are slightly over-excited, then the question of regulation is unimportant. My intention is not so much to call attention to differences in design as to draw your attention to the absolutely essential fact of stating what regulation you want to have on your generators, and how that regulation is to be tested when it comes to making the actual test.

Now, in regard to the question of margin. If a man buys a steam engine of 2,000 horse-power to drive his mill, he expects that at certain periods he may be capable of using that 2,000-hp engine as a 3,000-hp engine for a short period; in other words, he expects a margin of power. This point is only slowly being understood. Our esteemed president has some of our three-phase generators in his station at Denver, rated at 600 kilowatts, at 400 revolutions. In the Denver station the overload that comes on these generators at night is very great; as the generators are at present operated as single-phase machines, the load goes up to 700 kilowatts during the peak, and I was much pleased to hear that our generators pulled that load all right. The point I am making is this: the armature of the machine should be so designed that it can stand these large overloads for short periods. High-peripheral-speed machines, producing good fan effect, can be built with a regulation between six and eight per cent without a temperature rise of more than 30 degrees. These points are important, and I think you will excuse me for calling attention to them, because as a designer of machines I have had experience along these lines, and it seems to me that it is the duty of the designer to let you on this occasion profit by his experience, especially as your president has done me the honor of calling upon me to address you to-day.

THE PRESIDENT: We will ask Mr. Scott to close the discussion. Are there any further comments or remarks?

MR. JUNKERSFELD (Chicago): In this interesting and able discussion there is one point that comes to mind which is of vital interest to central-station men —the men that have to take the responsibility for a large investment and have to make returns on that investment. In the installation of a new system, or the reconstruction or modernizing or consolidating of one or more old systems, the prime consideration in each case will be, which system will have the greatest earning power for a given investment? The two gentlemen who have just spoken agree that in the largest installations three-phase is preferable. In the smaller installations, it is claimed that two-phase is equally good. This may be true when compared with the three-wire, three-phase. In most cases, however, I do not believe that it is true when compared with the four-wire, three-phase. We are operating in

Chicago a four-wire, three-phase system of primary distribution, which at the generator gives 2,300 volts between neutral and any one of the outside terminals and 4,000 volts between any two of the outside terminals. The first generators for such a system were installed about three years ago. The satisfaction given has been such that the Commonwealth Electric Company, of Chicago, has since then adopted this system for its entire territory, and will in a few months have about 5,000-kw capacity installed. We have found that this system is well adapted for carrying single-phase lighting on standard transformers having 2,080-volt primaries. Such a lighting circuit consists of the neutral and one-phase wire. In order to carry power business in close proximity to such single-phase lighting, it is only necessary to run two additional wires for bringing out the other two phases from generator. We then have lighting transmission at 2,300 volts and power transmission at 4,000 volts, with one wire of original lighting circuit used for both transmissions. Motors can thus be operated in connection with lighting circuits for very much less copper investment than with two-phase systems. There are two voltages available from the same generator and we use the higher for three-phase transmission motors. The heavy starting currents of induction motors requiring full torque are, therefore, correspondingly less, and give no trouble on the lighting circuits. It is also a great advantage to be able to use the higher voltage either for single-phase or for three-phase transmission to more distant localities, and thus over a larger territory. For first-class service, independent feeder regulators are necessary in any case, with either two-phase or three-phase.

The central-station man, even if present business is small, must be ready eventually to take any business that comes his way. His ambition should be to build up a larger business, and in planning new installations he should look ahead, even at a little temporary sacrifice. I believe that the four-wire, three-phase can be placed at least on an equal basis with the two-phase for small installations as well as for large installations.

MR. BERTRAND (Peoria, Ill.): The matter referred to comes in connection with three-phase secondary distribution, using four wires, as has been noted here, connecting motors to the three outside wires, and lights to either of the three outside wires and neutral wire. It is cumbersome, however, to use single-phase transformers, as it is necessary to use a greater number of small units.

MR. KELSCH: We have in Montreal eight 1,000-kw, three-phase, 60-cycle generators operated in multiple on a three-wire, three-phase system. We are using three-phase induction motors, and we have no more difficulty in balancing our three-phase system than is encountered in three-wire Edison system. We consider that the three-phase motor has an advantage in being operated from three transformers. In the event of one transformer failing, the two remaining transfomers can be readily connected up so that the service is re-established in a very short time. We have no difficulty in our lighting work. Where we have large lighting installations of 2,000 to 5,000 lights, we divide this load up on the three-phase system by supplying three-phase, two-phase transformers. We are operating all classes of electrical apparatus, including rotary converters, induction motors from one-half to 400-kw capacity, and synchronous motors of 150-kw capacity. We consider that the three-phase has additional advantages, aside from the saving of copper, consisting in reducing the number of wires required on the pole lines, which is an important item in a crowded city.

THE PRESIDENT: Shall we hear from you now, Mr. Scott?

MR. SCOTT: I think the fact that the central-station men are telling what they are using and how they like it, is valuable, and if there are others who will speak, I suggest that they be called upon.

THE PRESIDENT: The idea in this discussion, gentlemen, was to get one man to represent the three-phase side and another man to represent the two-phase side. We asked Mr. Scott to take the two-phase side. He did not care to do that, but wanted to tell the advantages of both. We asked him to lay stress on the two-phase side, to see if we could not have a discussion. I think, as the discussion now stands, no one would go away with any clear idea as to whether we should use two-phase or three-phase, and none of us will have changed his mind at this juncture. If there is anyone who has distinct views on the use of two-phase as against the three-phase, we shall be glad to hear from him.

MR. GOSSLER: In regard to the two-phase distribution, I may say that we are supplying from our general system, operated from generators running in parallel, about 150,000 incandescent lamps and somewhere in the neighborhood of 10,000 horse-power; all from the same distribution system. We pay very little or no attention to dividing the load equally between the phases; we practically give it no consideration whatever.

MR. HOLMES (Newton, Mass.): We are operating a two-phase system as single-phase and we have no trouble. We do not pay much attention to the balancing up, and do not think we need do so. We operate small single-phase induction motors on separate transformers on lighting circuits and also operate four or five small two-phase motors of three horse-power on these mains. We carry quite an unbalanced load, and it does not bother us at all on our lighting.

MR. GILCHRIST: I should like to have an answer to the question as to what can be said particularly against the two-phase system for isolated plants. There have been several two-phase isolated plants put in in Chicago. Naturally, even if we can not get the business at the start, we are anxious to see three-phase plants put in—that being our system—so that we can later get hold of them without involving too much investment. If there are any arguments that we can use with isolated plants in favor of three-phase against two-phase, I should like to know of them.

MR. KELSCH: I should like to hear from any other central-station man who is operating a two-phase system, who does not pay any attention to balancing the load.

MR. BEHREND: The phases in two-phase generators are no more independent than in three-phase generators. Although they seem independent of each other electrically, they are connected magnetically through the fields; hence, any change of load in one phase affects the other.

MR. P. M. LINCOLN: We are operating a two-phase system at Niagara Falls, and about 40 per cent of the load is single-phase. We find it necessary in that case to have our two phases pretty evenly balanced. If we do not, we find that the induction motors, particularly, on our system heat up a good deal more than they would otherwise, because the tendency of any induction motor is to balance up between the two phases; and in cases of too large unbalancing the tendency of the motor to balance results in taking power from one phase and delivering it to the other at the expense of heating the motor. We find it necessary to balance the two phases pretty closely to avoid this trouble.

THE PRESIDENT: If there is no further discussion, we shall be pleased to hear from Mr. Scott.

MR. SCOTT: One of the first things mentioned in the discussion was one that, in certain of its bearings, is of vital interest to this association. It is the four-wire, three-phase system; 2,300 volts from the neutral to each wire and 4,000 volts on the outside circuit. Do you realize that an underwriters' rule has been prepared and proposed which would keep these 4,000-volt circuits 75 feet away from any building? This suggestion is sufficient, as the committee on Underwriters' Rules of this association will see what that means.

A word of caution regarding high voltages may be in place. It is inevitable that the difficulties in the installation and keeping up of a plant at 4,000 volts will be more than at 2,000 or 2,300 volts. While a large and well-operated plant, with good supervision and care, can operate at 4,000 volts, it, nevertheless, may be an injudicious thing to use this voltage in smaller plants, where the care and attendance is naturally not so good and where the requirements for higher voltage are not so great.

With regard to higher voltages, particularly in the case of transmission lines, a gentleman presented to me a few weeks ago a plan that he had for a transmission plant. He proposed to run at 30,000 volts and to run two circuits on the same pole line. I told him I thought he was getting high in voltage, and that the circuits were pretty close together; but that I would look over the estimate he had made covering all parts of the plant. I found that the cost of copper in the transmission line was only about one per cent of the total cost of the plant, and that the cost of pole line, right of way and copper amounted to only two or three per cent. Now, considering water-wheels, generators, switchboards, transmission lines, sub-stations,—considering the whole problem—the thing that would naturally be looked upon as the one upon which the most care should be expended is the high-voltage transmission line for 30 or 40 miles through a desolate country; and yet he had that part down to about three per cent of the total cost. I explained to him that I thought his co-efficient of reliability would be greatly enhanced by adding a few per cent to the cost of his transmission line, and when he revised his figures he had two pole lines instead of one, and at 20,000 volts instead of at 30,000. In another case that came to my notice a short time ago, I happened to see the plan that had been adopted for the poles for carrying two 30,000-volt circuits. It was good, substantial construction; insulators on short pins, coming within an inch or so of the cross-arms; the cross-arms provided with iron braces and the insulators with metal pins. It was excellent insulation for 1,000 or 2,000 volts, but the man showed entire ignorance of the requirements of a 30,000-volt line. It happened that a gentleman from the West, who was operating a 30,000-volt plant, was in my office, and I showed him the blue print, and he thought there would be a merry time there when the volts began to act.

The three-phase transformer has been spoken of: that is, one transformer that would take three-phase current and deliver three-phase current. I have been trying for some time to figure out with Mr. Peck, our transformer designer, just wherein lies the advantage of a three-phase transformer over three single-phase transformers. There are some theoretical advantages,—such as less material—but when it comes to building the transformers, the gain in efficiency and in cost is not much, and it is at considerable sacrifice in handling. Instead of having three units, one of which you can take away while using the other two temporarily, as has been suggested, you have all your eggs in one little basket; and I fail to see where the advantage accrues in a construction of that kind. I am also of the opinion that the four-wire, three-phase secondary distribution can not be very successfully conducted without the neutral wire from the generator also.

Nearly all the gentlemen who spoke in regard to lighting on three-phase and two-phase systems represented the larger stations. The gentleman who spoke for Montreal began with the statement that he had so many thousand kilowatt generators, and it is probable that he could distribute anywhere from such large generating capacity. There would be little occasion for any great unbalancing, and his regulation would be of a high order. It was mentioned, also, that the lighting in one case was by three-phase, two-phase transformers, and was found to be successful.

One thing is notable in this discussion by the central-station men: they have considered lighting and the matter of balancing loads, but they have not referred particularly to motor work. The lighting work alone has been a thing of the past; but lighting and motor work—the combination of the two—is to be the work of the future; and the more definitely you look forward to and plan for that work, the greater will be your success in the future.

THE PRESIDENT: Before we go on with some of the questions relating to this subject, I want to appoint certain committees that should have been appointed sooner.

Committee on Memorials: Messrs. E. H. Davis, Williamsport, Pa.; F. E. Smith, Somerville, Mass., and W. E. Moore, Augusta, Ga.

Committee on Nominations: Messrs. Frederic Nicholls, Toronto, Canada; James I. Ayer, Boston, and H. H. Fairbanks, Worcester, Mass.

Committee on Amendments to the Constitution, to be added to the former committee: Messrs. C. L. Edgar, Boston; G. E. Hay, Springfield, Ill., and Frederic Nicholls, Toronto, Canada.

I want to call your attention to a criticism made on the form of programme that we are now following. We tried it at a meeting of the Ohio Gas Light Association, and it proved instructive. One of the delegates came to me at that convention and said, "I am like the farmer, I don't want to hear both sides of a question; it always confuses me." But we do want to hear both sides of these questions. We will now take up a few questions allied to the discussion that we have just had.

(Questions Nos. 70, 1, 2, 3 and 30 were taken up. See Question Box.)

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THE PRESIDENT: We will now take up the report of the committee on Standard Rules for Electrical

Construction and Operation, of which Captain William Brophy, of Boston, is chairman. Have you a report, Captain Brophy, for the committee on standard rules.

CAPTAIN BROPHY: The only question of importance to this association, so far as standard rules go, that has developed during the past year, is the proposed amendment to the rules, which will practically exclude from the streets of every city and town all alternating currents having a difference of potential above 3,500 volts. If that rule is enforced, the four-wire system described here can not be used, and the wires will not be permitted to come within 75 feet of a building. It requires a private right of way for all high-tension alternating circuits, or else they must go underground. I have endeavored to meet the question by showing the inconsistency of the thing. We have to-day series-arc circuits with a difference of potential at the 'bus-bars of over 8,000 volts. If 3,500 volts alternating is dangerous, certainly the 8,000-volt series-arc circuits are dangerous.

Your committee desires instructions as to what course it shall pursue in meeting this proposed amendment, and your committee would like to hear the views of the members of the association, so that the committee may take such ground as the association deems necessary and proper, although we are satisfied ourselves as to what position we should take. The way in which I have combated the amendment thus far, is by showing the inconsistency of the rule.

THE PRESIDENT: Is there any method you would suggest?

CAPTAIN BROPHY: The next method we would suggest would be to question the right of any organization doing a commercial business-- which the Board of Underwriters is doing—to hamper the business of any other class of people doing a legitimate business. In the first place, the underwriters have no control over the wires in the streets or under the streets, except as they may affect the matter by increasing insurance rates generally. They have no legal right to do it, and it may be necessary to meet that. Whether or not they can destroy the business of the people engaged in the electric-light business, is a serious question. Unfortunately, one of the troubles of the underwriters' association in relation to the code, is that it has very little conception of the amount of damage that can be done by rendering obsolete standard articles that cost thousands of dollars, which are now in the hands of people doing a lighting and power business. They evidently do not stop to think of that, but it is a matter of the greatest importance to those who are in the electric-lighting business, who would be affected by any arbitrary rule of this character that they might make.

THE PRESIDENT: Captain Brophy desires suggestions as to how his committee should proceed in order to overcome the adoption of this rule proposed by the Board of Underwriters.

MR. ABBOTT (Chicago): I do not think it is possible to enforce this rule, and I do not think the underwriters expect to do so. To show how absurd it would be to attempt its enforcement, I will say that we have in the city of Chicago over 50 miles of pole lines carrying 4,000 volts and over. Any building that is approached within 75 feet by these lines would be subject to this rise in the rate of insurance, and any other line with which it comes in proximity will affect the buildings along its course in the same way. We are crossing telephone wires, telegraph wires, fire-alarm wires, and other wires, in all directions, and these wires are ramified all over the city, so that practically, to enforce this rule, they would have to raise the rates on the entire city of Chicago.

THE PRESIDENT: Can anyone give Captain Brophy any assistance? He desires to proceed in the best manner possible to overcome the adoption of the proposed rule.

MR. PRICE: What does Captain Brophy suggest?

THE PRESIDENT: He suggests bringing these matters to the attention of the Board of Underwriters.

CAPTAIN BROPHY: I feel, as chairman of the committee, that it is desirable to separate low-tension wires—such as telegraph, telephone and signal wires—as widely as possible from high-tension wires. We all agree to that. My opinion is that if these wires are kept separated from all other wires, and the circuits so constructed where they do cross that it will be difficult for them to come in contact, it will not be necessary to enforce this rule. I shall of course, do all that I can to show the Board of Underwriters that it is unwise to pass this rule. It is now in the hands of a committee to be reported upon. What their report will be, I do not know. I believe the original committee practically acceded to the passage of this rule; but the committee has been added to, and I think that men of larger experience in such matters have been added to the committee, and I hope the final result will be different from what it was at first.

MR. LINCOLN: As I understand it, this rule of the underwriters places all circuits of over 3,500 volts on a par. It seems to me that it is absurd to treat a transmission circuit of 4,000 volts in the same class as a 40,000-volt transmission circuit, and that is one of the inconsistencies that should be brought to their attention.

CAPTAIN BROPHY: That is true. But there are other inconsistencies. If the association has no instructions, the committee will use its best endeavors to point out to the underwriters the inconsistencies of the proposed amendment and the great complications that would follow its adoption.

THE PRESIDENT: I think that is the sentiment of this convention: that the committee should use its best endeavors to convince the underwriters that it is not good policy to enforce this rule.

MR. PRICE: I suggest that the committee on standard rules propose to this association a form of remonstrance against this amendment, upon which we can vote, so that the committee may be somewhat better prepared to resist the adoption of the proposed rule.

THE PRESIDENT: I think it is advisable to save time, and I suggest that Captain Brophy draw up a resolution, or ask the secretary to do so, and we will pass it and thus give the committee on standard rules the support of the association in its efforts.

We will now take up the consideration of more of the topical questions. Questions Nos. 26, 27 and 28, which relate to grounding the neutral, will be considered in executive session.

(Questions Nos. 68, 31, 32 and 36 were then taken up. See Question Box.)

(The meeting then adjourned until two p. m.)

# FIFTH SESSION

The meeting was called to order by President Doherty at ten minutes after two o'clock, and the consideration of topical questions was continued, including questions Nos. 7, 9, 14 and 20, for which see Question Box.

THE PRESIDENT: We will now ask Professor C. P. Matthews, of Purdue University, to present the third progress report of the Committee for Investigating the Photometric Values of Arc Lamps.

# REPORT OF THE COMMITTEE FOR INVESTIGATING THE PHOTOMETRIC VALUES OF ARC LAMPS

*Mr. President and Gentlemen of the National Electric Light Association:*

Your committee appointed to investigate the photometric value of arc lamps, submits to you herewith its third progress report of the work intrusted to its care.

During the present year, an effort has been made to carry out a comprehensive and comparative study of the open and inclosed types of series arc lamps, in view of the great attention that has been directed to the use of series inclosed arc lamps in street lighting during the past few years. The records, which are included in the appended report of the photometrist to the committee, contain much valuable information bearing upon this subject, and it is hoped that it will serve to clear up, in the minds of the membership of this association, a number of disputed points as regards the relative merits of the various types of lamps and arc settings tested.

Your committee would direct special attention to the results which are recorded under Section 6 of the appended report. These results show the illumination on a plane normal to the ray at different points along the street for direct-current, open and inclosed lamps, together with the effect of changing the height of these lamps upon such illuminations.

Your committee would again acknowledge its obligation to the School of Electrical Engineering, Purdue University, for the great service it has rendered in making the carrying out of these tests possible.

(Signed) Henry L. Doherty, Chairman
W. E. Goldsborough
J. Q. Brown

## TREASURER'S REPORT

Mr. Henry L. Doherty,
Chairman of the Committee on Arc-Light Photometry.

Dear Sir: As acting treasurer of your committee, I submit a report of moneys received and expended by me in behalf of your committee.

| | |
|---|---|
| **Dr.** | |
| Balance from statement previously rendered | $101 18 |
| Amount of Arc Light Fund received by drafts from the Treasurer of the National Electric Light Association, to be applied to the expenses of the committee in conducting tests | 205 00 |
| Total | $306 18 |
| **Cr.** | |
| Salary of one full-time assistant | $250 00 |
| Extra assistance employed at irregular intervals | 45 00 |
| Miscellaneous materials used in fitting up laboratory for photometric research work, etc. | 11 18 |
| Total | $306 18 |

W. E. Goldsborough,
Acting Treasurer of Committee on Arc-Light Photometry.

*To the Committee of the National Electric Light Association on the Photometric Value of Arc Lamps:*

I take pleasure in transmitting to you herewith a third progress report on the photometric tests of inclosed-arc lamps, which I have received from Professor Matthews.

Yours very truly,
W. E. Goldsborough.

PROFESSOR W. E. GOLDSBOROUGH,
Director of Electrical Laboratory, Purdue University.

DEAR SIR: I submit herein a record of the tests that have been carried out for your committee since the date of my last report. Particular attention has been given to the performance of series arcs of both the open and inclosed types. The methods and apparatus used have been substantially those developed and described in the work of previous years. The material in the following pages may properly be classified as follows:

I. Tests of 6.6-ampere, direct-current inclosed-arc lamps in their commercial forms.

II. Similar tests of 6.6-ampere alternating-current inclosed-arc lamps.

III. Also tests of 7.5-ampere alternating-current inclosed-arc lamps.

IV. Tests of a 450-watt arc under varying conditions of energy supply, etc.

V. Tests of various brands of high and low-grade carbons in a 9.5-ampere open arc.

VI. A consideration of the illumination produced on a plane normal to the ray at different distances from the lamp; the mean value of this illumination between chosen limits; and, finally, the effect upon these quantities of a variation in the height of the lamp.

## UNITS

As the writer's use of the Hefner unit in the reports of previous years has met with some criticism, it would seem appropriate that some explanation of this usage should be made. While the Hefner-Alteneck amyl-acetate lamp is far from being a perfect primary standard, it is quite generally acknowledged to be superior to the candle, especially in respect to its constancy and reproducibility. This fact has caused the formal adoption of the Hefner unit in Germany, a rapidly increasing use in France, where the Carcel lamp has heretofore held such sway, and an almost universal use in the physical laboratories of the world.

In 1897 a committee of the American Institute of Electrical Engineers recommended "That Hefner-Alteneck amyl-acetate lamps * * * should be temporarily adopted as concrete standards of luminous intensity or candle-power."[1] It will be noted that the Hefner lamp, and not the Hefner unit, is here adopted. If for commercial or other reasons it becomes necessary to change results from Hefner units to British candles, the question immediately arises—what ratio shall be used?

To answer this question truly is a difficult, if not an impossible, matter, because successive determinations of the British candle are not determinations really of the same thing.

Evidence of the unreliable character of the candle is not lacking. A few quotations from an extensive report of a committee of the American Institute of Electrical Engineers[2] may suffice for the present writing.

"A committee of the British Association, comprising numerous distinguished members of that body, in their fourth report, rendered at the Plymouth meeting in 1888, gave the results of extensive tests on candles * * * They concluded that candles are not worthy to be called standards, although they conform to the

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(1) See the proceedings of the Geneva Congress of Electricians, 1896.

(2) Report of Nichols, Sharp and Matthews.
Transactions XIII: 133. 1896.

legal requirements, and that the intensity of their light is affected by the purity of the air in the room, the shape and construction of the wick, the nature of the sperm, and by other causes." Again, "Heisch and Hartley, acting for the committee on light standards of the Council of the Gas Institute, found that the difference in the illuminating power of candles ranged from 1.3 per cent to 16 per cent, the average difference being 7.05 per cent." Dibdin "found in his first series of tests a maximum variation of 14.9 per cent, which occurred twice, and a maximum total variation in a single group of 23.2 per cent, which also occurred twice."

As to the performance of the Hefner lamp, I quote from the same report as follows: "Dibdin, indeed, made rather extensive tests of it and found excellent results as far as steadiness goes, 90 per cent of the tests being within one per cent of the mean, and this in spite of the fact that he took the perhaps unwarrantable liberty of increasing the flame height to 51 min., *to make the intensity of the lamp equal to that of the British candle.* The committee of the British Association found only four among 118 tests which deviated more than two per cent from the mean, and 11 which deviated more than one per cent from the mean."

The disadvantages of the Hefner light are its reddish color and its instability of flame. Like all flame standards, it is influenced by atmospheric conditions. Pressure, moisture and carbon dioxide are factors that must be taken into consideration in the most accurate use of the source.

In the light of an abundance of evidence such as the foregoing, it is easy to see why attempts to evaluate the candle in terms of the Hefner unit should yield discordant results. Were it not for the fact that it is desirable to secure some comparison between the great bulk of photometric measurements made upon English, German and French candles as bases and measurements made upon the Hefner unit base, it would perhaps be better to abandon such attempts. The accepted ratio, whatever value it may have, partakes of the nature of an arbitrarily chosen constant.

Some values of the ratio Hefner unit: British candle obtained by competent investigators are:

| | |
|---|---|
| German Soc. Gas Engineers | .886 |
| German Reichsanstalt [1] | .876 |
| Sharp (Candles reduced for rate) [2] | .872 |
| Sharp (Candles reduced for flame height) [2] | .892 |
| Netherland Photometry Commission | .921 |
| S. Schiele [3] | .881 |

The American Institute of Electrical Engineers' committee says in reference to these determinations: "The preponderance of evidence in favor of the value .88 is very great." It should be noted, however, that Violle found a value of .98 for this ratio. The mean value of the six foregoing determinations is .888.

In this connection, a quotation from a letter recently received from Dr. C. H. Sharp, test officer of the Lamp Testing Bureau is of interest. "So far as I know, the best way to arrive at the value of the British candle-power is to start from the Hefner

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(1) Zeitschrift fur Instrumentenkunde 13:257. The mean of a long series of determinations by different observers using candles from various sources.

(2) Trans. A. I. E. E. 1896.

(3) Journal fur Gasbeleuchtung und Wasserversorgung, 1889, XXXII: 757.

lamp as a primary standard and to reduce its indications according to the accepted value for the ratio of the luminous intensity of the Hefner light to that of the British candle."

If, now, the British candle be defined as 1.14 Hefner units, we have a fairly concrete standard and there can be no objection to the use of the term *candle-power* thus defined. With this thought in mind, I have tabulated most of the results in the following pages in terms of candle-power, paralleled, in order that ready comparison may be made with the results of the two previous reports, by the corresponding values in Hefner units. The curves, however, are plotted in the candle-power unit.

## I. TESTS OF 6.6-AMPERE, CONSTANT DIRECT-CURRENT LAMPS

For the purpose of securing data on the performance of this important type of street illuminant, six lamps, representing three well-known brands, were tested for candle-power and energy consumption. The luminous intensity was measured at 15° intervals from 15° above the horizontal to 75° below. Figure 1 shows graphically the results obtained, the lamps being fitted with opalescent inner and clear outer globes. The lamps are numbered and classified as follows:

| | |
|---|---|
| Brand W—Nos. | 68, 69, 70 |
| Brand U— | 71 |
| Brand T— | 75, 76 |

In Figure 1, the results on the individual lamps are shown in light lines, and the mean of all in the heavy broken line. This type is seen to give from 360 to

410 candle-power in the most useful directions. While there is considerable variation among the curves of separate lamps, the mean of all is a curve of remarkable smoothness. This curve shows what may be expected on the average from this type of lamp.

Figure 2 shows the performance of the same lamps with clear outer globe removed. It is to be noted that the clear globe produces the usual rounding effect on the curves, drawing them closer to the mean and reducing them somewhat by absorption. In Figure 1, lamps 75 and 76 are shown as somewhat stronger near the horizontal than the others. This

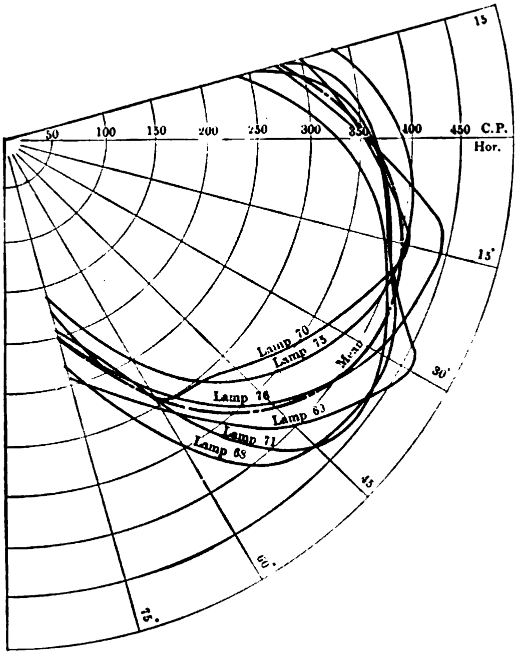

Fig. 1—Distribution of Candle Power, 6.6-Ampere, Constant Direct-Current Lamps with Opalescent Inner and Clear Outer Globes

effect is intensified when the outer is removed. The greater the tendency of the candle-power curve to slant away from the arc in passing from 15° B to the horizontal, the more effective the lamp for street lighting. It is significant that the curve to show this desirable feature to the least extent is that of lamp 71. This lamp had an open-base inner globe; all others were fitted with closed-base inners. This points to the conclusion that, for street lighting, best distribution is obtained with closed-base inner globes. The numerical data for these tests are given in tables I to IV.

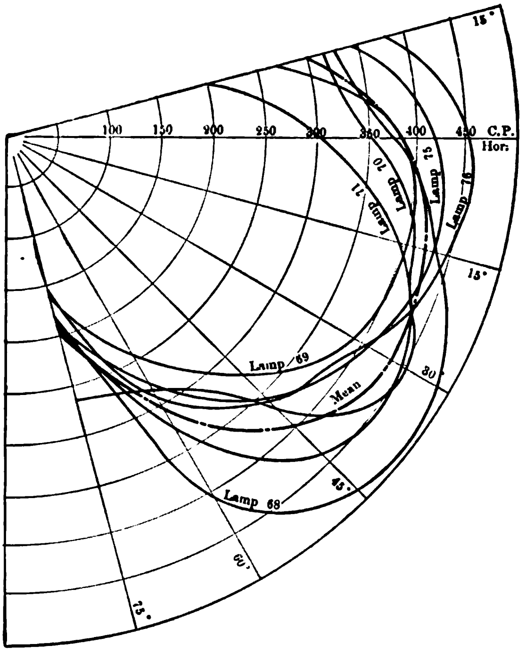

FIG. 2—DISTRIBUTION OF CANDLE POWER, 6.6-AMPERE, CONSTANT DIRECT-CURRENT LAMPS WITH OPALESCENT INNER GLOBE ONLY

# TABLE I

## D. C. SERIES 6.5 AMPERES

### Lamp 68

| Angle | Luminous Intensity | | | |
|---|---|---|---|---|
| | H. U. | C. P. | H. U. | C. P. |
| 15° A | 373 | 328 | 328 | 288 |
| Hor. | 429 | 377 | 411 | 362 |
| 15° B | 491 | 431 | 446 | 392 |
| 30° B | 558 | 491 | 490 | 431 |
| 45° B | 556 | 490 | 485 | 427 |
| 60° B | 455 | 400 | 398 | 350 |
| 75° B | 206 | 181 | 267 | 235 |

| Globes | No Outer Opalescent Inner | Clear Outer Opalescent Inner |
|---|---|---|
| E. M. F. | 68. | |
| Current | 6.5 | |
| Watts | 442. | |
| Mean Hemispherical Candle Power | 414. | 370. |
| Watts per Mean Hemispherical Candle Power | 1.07 | 1.2 |

# TABLE II

## D. C. SERIES 6.5 AMPERES

### Lamp 69

| Angle | Luminous Intensity | | | |
|---|---|---|---|---|
| | H. U. | C. P. | H. U. | C. P. |
| 15° A | 302 | 266 | 291 | 256 |
| Hor. | 445 | 392 | 413 | 364 |
| 15° B | 465 | 409 | 442 | 389 |
| 30° B | 461 | 406 | 524 | 460 |
| 45° B | 363 | 319 | 428 | 377 |
| 60° B | 274 | 241 | 348 | 306 |
| 75° B | 184 | 162 | 274 | 241 |

| Globes | No Outer Opalescent Inner | Clear Outer Opalescent Inner |
|---|---|---|
| E. M. F. | 73. | |
| Current | 6.5 | |
| Watts | 475. | |
| Mean Hemispherical Candle Power | 347. | 368. |
| Watts per Mean Hemispherical Candle Power | 1.37 | 1.29 |

# TABLE III

## D. C. SERIES 6.5 AMPERES

### LAMP 70

| Angle | Luminous Intensity | | | |
|---|---|---|---|---|
| | H. U. | C. P. | H. U. | C. P. |
| 15° A | 360 | 316 | 342 | 301 |
| Hor. | 404 | 355 | 404 | 356 |
| 15° B | 471 | 415 | 465 | 410 |
| 30° B | 515 | 452 | 414 | 364 |
| 45° B | 432 | 380 | 362 | 319 |
| 60° B | 324 | 286 | 332 | 292 |
| 75° B | 302 | 266 | 200 | 176 |

| Globes | No Outer Opalescent Inner | Clear Outer Opalescent Inner |
|---|---|---|
| E. M. F. | 71.3 | |
| Current | 6.5 | |
| Watts | 463. | |
| Mean Hemispherical Candle Power | 372. | 342. |
| Watts per Mean Hemispherical Candle Power | 1.24 | 1.35 |

# TABLE IV

## D. C. SERIES 6.6 AMPERES

### LAMP 71

| Angle | Luminous Intensity | | | |
|---|---|---|---|---|
| | H. U. | C. P. | H. U. | C. P. |
| 15° A | 224 | 197 | 272 | 239 |
| Hor. | 348 | 306 | 371 | 326 |
| 15° B | 451 | 397 | 434 | 382 |
| 30° B | 514 | 451 | 486 | 427 |
| 45° B | 500 | 440 | 488 | 430 |
| 60° B | 372 | 328 | 329 | 290 |
| 75° B | 206 | 181 | 220 | 193 |

| Globes | No Outer Opalescent Inner | Clear Outer Opalescent Inner |
|---|---|---|
| E. M. F. | 67.8 | |
| Current | 6.6 | |
| Watts | 447. | |
| Mean Hemispherical Candle Power | 353. | 360. |
| Watts per Mean Hemispherical Candle Power | 1.27 | 1.24 |

## TABLE V

### D. C. SERIES 6.6 AMPERES

### LAMP 75

| Angle | Luminous Intensity | | | |
|---|---|---|---|---|
| | H. U | C. P. | H. U. | C. P. |
| 15° A | 392 | 344 | 380 | 334 |
| Hor. | 475 | 418 | 444 | 391 |
| 15° B | 497 | 439 | 460 | 405 |
| 30° B | 467 | 411 | 436 | 384 |
| 45° B | 413 | 364 | 378 | 333 |
| 60° B | 312 | 275 | 282 | 248 |
| 75° B | 215 | 189 | 179 | 158 |
| Globes | No Outer Opalescent Inner | | Clear Outer Opalescent Inner | |
| E. M. F. | 73.8 | | | |
| Current | 6.6 | | | |
| Watts | 487. | | | |
| Mean Hemispherical Candle Power | 375. | | 353. | |
| Watts per Mean Hemispherical Candle Power | 1.3 | | 1.38 | |

## TABLE VI

### D. C. SERIES 6.6 AMPERES

### LAMP 76

| Angle | Luminous Intensity | | | |
|---|---|---|---|---|
| | H. U. | C. P. | H. U. | C. P. |
| 15° A | 431 | 380 | 314 | 276 |
| Hor. | 520 | 458 | 405 | 356 |
| 15° B | 503 | 443 | 505 | 445 |
| 30° B | 453 | 400 | 477 | 420 |
| 45° B | 436 | 384 | 415 | 365 |
| 60° B | 330 | 290 | 325 | 286 |
| 75° B | 190 | 167 | 228 | 201 |
| Globes | No Outer Opalescent Inner | | Clear Outer Opalescent Inner | |
| E. M. F. | 76. | | | |
| Current | 6.6 | | | |
| Watts | 501. | | | |
| Mean Hemispherical Candle Power | 390. | | 366. | |
| Watts per Mean Hemispherical Candle Power | 1.28 | | 1.37 | |

## II. TESTS OF 6.6-AMPERE, CONSTANT ALTERNATING-CURRENT LAMPS

Three lamps of this type, with globe fittings, as follows:

(a) Opalescent inner, clear outer

(b) Opalescent inner only

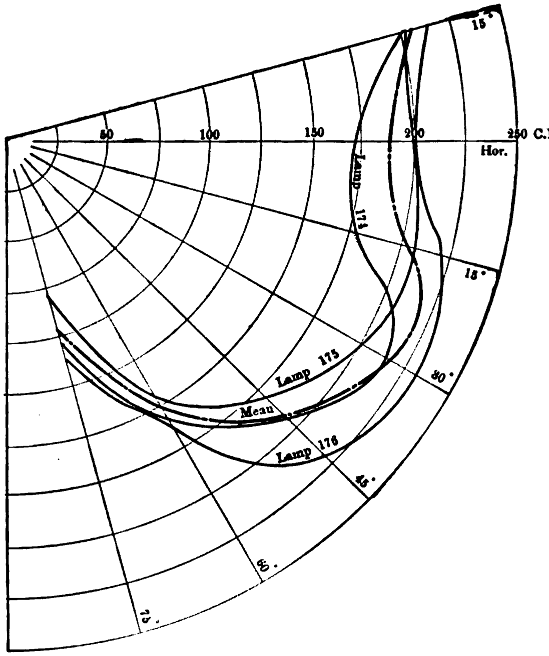

FIG. 3—DISTRIBUTION OF CANDLE POWER, 6.6-AMPERE, CONSTANT ALTERNATING-CURRENT LAMPS WITH OPALESCENT INNER AND CLEAR OUTER GLOBES

(c) Opalescent inner and street shade were subjected to careful tests for luminous intensity and power consumption. The results are to be found in Tables VII, VIII and IX, the corresponding candle-power curves throughout the lower hemisphere being shown in Figures 3, 4 and 5.

The lamps are referred to as 174, 175 and 176. In Figure 5, lamp 174 has been replaced by lamp 268 of last year's data.

Figure 3 shows that the mean curve of the alternating 6.6-ampere lamp with clear outer globe, ranges from 190 candle-power in the horizontal to 220 candle-power at 30° B. These values are much less than the corresponding values for the 6.6-ampere, direct-current lamp with similar globes. The power consumption of the alternating lamp is considerably smaller —a matter discussed further on in this report.

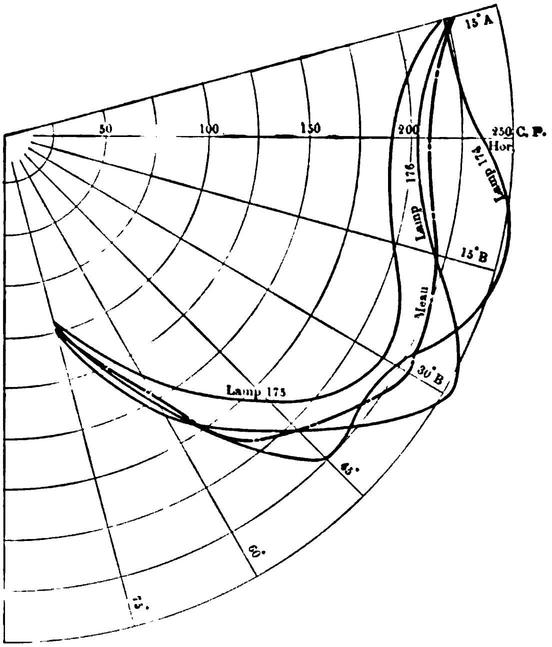

FIG. 4—DISTRIBUTION OF CANDLE POWER, 6.6-AMPERE CONSTANT ALTERNATING-CURRENT LAMPS WITH OPALESCENT INNER GLOBE ONLY

Figure 4 shows the usual effect of a divergence of the individual curves from the mean when lamp is used with inner globe only. What seems to be an anomaly occurs in the case of lamps 175 and 176. The tables show for the one the same mean *hemispherical* candle-power with and without clear outer globe, and for the other a slightly increased candle-power *with* outer globe. To assure myself that this was not an error, I had the observations repeated, but the result came out the same. It can readily be understood when it is remembered that we are dealing here with the mean hemispherical candle-power. While

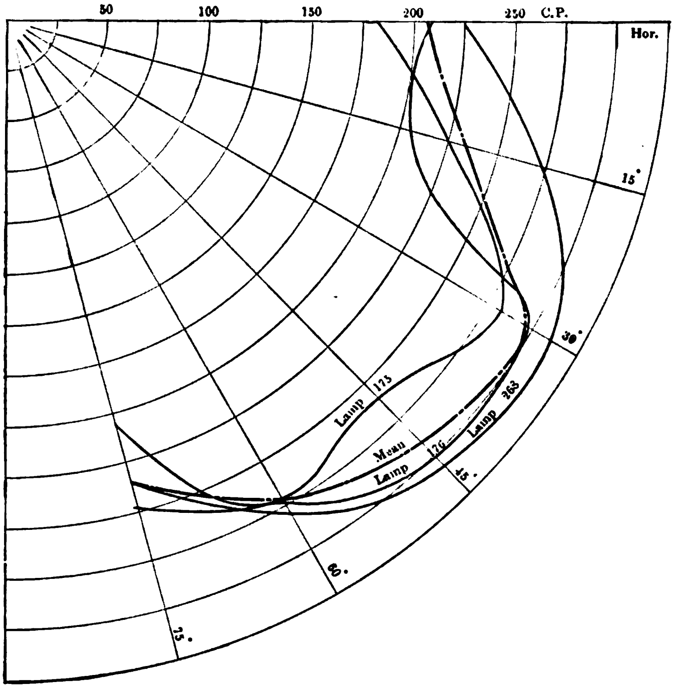

Fig. 5—Distribution of Candle Power, 6.6-Ampere, Constant Alternating-Current Lamps with Opalescent Inner Globe and Street Shade

# TABLE VII

## A. C. SERIES 6.6 AMPERES

### LAMP 174

| Angle | Luminous Intensity | | | |
|---|---|---|---|---|
| | H. U. | C. P. | H. U | C. P. |
| 15° A | 252 | 222 | 225 | 196 |
| Hor. | 263 | 231 | 193 | 170 |
| 15° B | 274 | 241 | 201 | 177 |
| 30° B | 250 | 220 | 243 | 214 |
| 45° B | 253 | 223 | 212 | 187 |
| 60° B | 166 | 146 | 177 | 156 |
| 75° B | 109 | 96 | 114 | 100 |
| Globes | No Outer Opalescent Inner | | Clear Outer Opalescent Inner | |
| E. M. F. | 72.4 | | | |
| Current | 6.6 | | | |
| Apparent Power | 477. | | | |
| Watts | 403. | | | |
| Power Factor | .84 | | | |
| Mean Hemispherical Candle Power | 217. | | 179. | |
| Watts per Mean Hemispherical Candle Power | 1.86 | | 2.25 | |

# TABLE VIII

## A. C. SERIES 6.6 AMPERES

### LAMP 175

| Angle | Luminous Intensity | | | | | |
|---|---|---|---|---|---|---|
| | H. U. | C. P. | H. U. | C. P. | H. U. | C. P. |
| 15° A | 248 | 218 | 228 | 201 | | |
| Hor. | 213 | 188 | 228 | 201 | 206 | 181 |
| 15° B | 226 | 199 | 233 | 205 | 251 | 221 |
| 30° B | 245 | 216 | 221 | 195 | 320 | 282 |
| 45° B | 205 | 180 | 194 | 171 | 297 | 261 |
| 60° B | 154 | 134 | 162 | 143 | 309 | 272 |
| 75° B | 103 | 90 | 90 | 79 | 232 | 204 |
| Globes | No Outer Opal. Inner | | Clear Outer Opal. Inner | | Shade Opal. Inner | |
| E. M. F. | 63.7 | | | | | |
| Current | 6.6 | | | | | |
| Apparent Power | 420. | | | | | |
| Watts | 381. | | | | | |
| Power Factor | .91 | | | | | |
| Mean Hemispherical Candle Power | 185. | | 185. | | 244. | |
| Watts per Mean Hemispherical Candle Power | 2.06 | | 2.06 | | 1.56 | |

## TABLE IX

### A. C. SERIES 6.6 AMPERES

### LAMP 176

| Angle | Luminous Intensity | | | | | |
|---|---|---|---|---|---|---|
| | H. U. | C. P. | H. U. | C. P. | H. U. | C. P. |
| 15° A | 258 | 227 | 240 | 211 | | |
| Hor. | 228 | 201 | 217 | 191 | 238 | 210 |
| 15° B | 244 | 215 | 250 | 220 | 232 | 204 |
| 30° B | 289 | 254 | 261 | 230 | 336 | 296 |
| 45° B | 230 | 203 | 246 | 216 | 339 | 298 |
| 60° B | 189 | 166 | 175 | 154 | 310 | 273 |
| 75° B | 111 | 97 | 123 | 108 | 280 | 246 |
| Globes | No Outer Opal. Inner | | Clear Outer Opal. Inner | | Shade Opal. Inner | |
| E. M. F. | 60. | | | | | |
| Current | 6.6 | | | | | |
| Apparent Power | 396. | | | | | |
| Watts | 362. | | | | | |
| Power Factor | .91 | | | | | |
| Mean Hemispherical Candle Power | 205. | | 233. | | 252. | |
| Watts per Mean Hemispherical Candle Power | 1.76 | | 1.55 | | 1.44 | |

the clear globe can not make light, it may in some cases alter the distribution thereof in such manner as to strengthen the lower hemisphere at the expense of the upper, thus producing the result shown.

Figure 5 shows the effect of fitting this type of lamp with a street shade. This particular shade could probably be improved in design. Its effect is very strong in the region underneath the lamp out to the point determined by the 30° B ray. Attention was called in the first report to the necessity for careful design in the matter of shades in order to secure good results in street lighting.

### III. TESTS OF 7.5-AMPERE CONSTANT ALTERNATING-CURRENT LAMPS

As this type of lamp takes approximately the same power as the 6.6-ampere, direct-current lamp, its can-

# TABLE X

## A. C. SERIES 7.5 AMPERES

### LAMP 171

| Angle | Luminous Intensity | |
|---|---|---|
| | H. U. | C. P. |
| 15° A | 239 | 210 |
| Hor. | 223 | 196 |
| 15° B | 244 | 215 |
| 30° B | 235 | 207 |
| 45° B | 234 | 206 |
| 60° B | 193 | 170 |
| 75° B | 99 | 87 |

| Globes | No Outer<br>Opalescent Inner |
|---|---|
| E M. F | 75. |
| Current | 7.5 |
| Apparent Power | 563. |
| Watts | 441. |
| Power Factor | .79 |
| Mean Hemispherical Candle Power | 193. |
| Watts per Mean Hemispherical Candle Power | 2.28 |

# TABLE XI

## A. C. SERIES 7.5 AMPERES

### LAMP 172

| Angles | Luminous Intensity | |
|---|---|---|
| | H. U. | C. P. |
| 15° A | 280 | 246 |
| Hor. | 263 | 231 |
| 15° B | 275 | 242 |
| 30° B | 316 | 278 |
| 45° B | 314 | 276 |
| 60° B | 188 | 165 |
| 75° B | 138 | 122 |

| Globes | No Outer<br>Opalescent Inner |
|---|---|
| E. M. F | 67.4 |
| Current | 7.5 |
| Apparent Power | 505. |
| Watts | 455. |
| Power Factor | .9 |
| Mean Hemispherical Candle Power | 234. |
| Watts per Mean Hemispherical Candle Power | 1.94 |

## TABLE XII

### A. C. SERIES 7.5 AMPERES

LAMP 173

| Angle | Luminous Intensity | | | |
|---|---|---|---|---|
| | H. U. | C. P. | H. U. | C P. |
| 15° A | 215 | 189 | 235 | 207 |
| Hor. | 315 | 277 | 232 | 204 |
| 15° B | 327 | 288 | 256 | 225 |
| 30° B | 320 | 282 | 280 | 246 |
| 45° B | 311 | 274 | 278 | 245 |
| 60° B | 263 | 232 | 203 | 179 |
| 75° B | 131 | 115 | 116 | 102 |

| Globes | No Outer Opal. Inner | Clear Outer Opal. Inner |
|---|---|---|
| E. M. F. | 79. | |
| Current | 7.5 | |
| Apparent Power | 593. | |
| Watts | 472. | |
| Power Factor | .8 | |
| Mean Hemispherical Candle Power | 263. | 2.11 |
| Watts per Mean Hemispherical Candle Power | 1.8 | 2.24 |

dle-power curves are of some interest. Figure 6 and Tables X, XI and XII exhibit the results of several tests on lamps of this type (Nos. 171, 172 and 173). The distribution curves are quite similar in outline to those of the 6.6-ampere alternating lamp, but the candle power is strengthened in all directions, as, of course, it should be.

### COMPARISON OF THE THREE FOREGOING TYPES

Figure 7 shows in one diagram the mean curves taken from the figures that precede it. The relative value of the different types of lamps as producers of useful light below the horizontal plane through the arc is very well shown. To this figure, I have added curve S, which is taken from a 7.5-ampere alternating arc fitted with a shade whose action is superior to that of the shade on the 6.6-ampere lamps. The result of this is to bring the curve of the alternating lamp into close proximity to those of the 6.6-ampere direct-current lamps consuming approximately the same power.

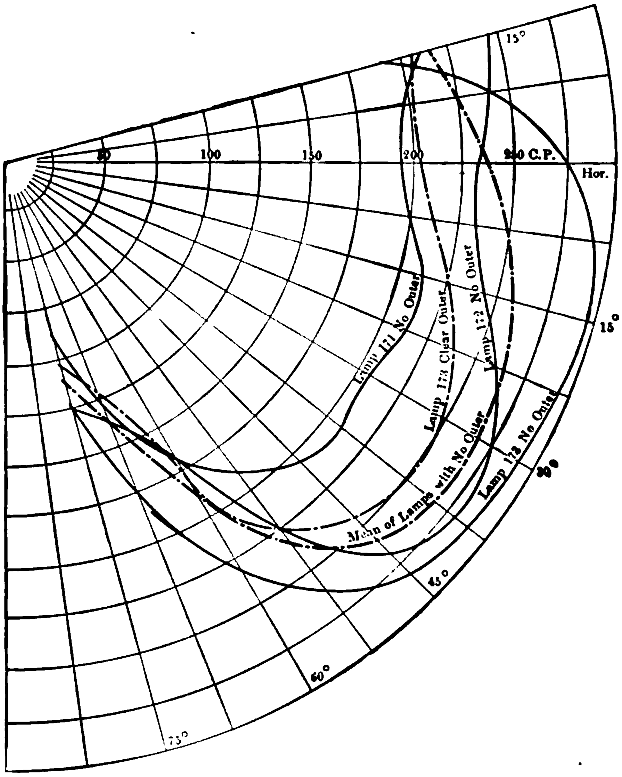

FIG. 6—DISTRIBUTION OF CANDLE POWER, 7.5-AMPERE, CONSTANT-ALTERNATING-CURRENT LAMPS WITH OPALESCENT INNER GLOBES AND OUTER GLOBES AS INDICATED

## SPECIFIC POWER CONSUMPTION

By this term is meant the watts per mean hemispherical candle power. The values below are obtained by dividing the average power consumption of all lamps of one type by the average value of the mean

hemispherical candle-power of all lamps of that type.
D. C. 6.6 amp. Op. inner, Cl. outer, 1.31 watts per c. p.
A. C. 6.6 amp. Op. inner, Cl. outer, 1.92 watts per c. p.
A. C. 6.6 amp. Op. inner, Shade.... 1.48 watts per c. p.

These figures show that while the alternating lamp taking 6.6 amperes is inferior to the direct-current lamp of the same current capacity in light-producing power below the horizontal, the use of a shade on the former brings down its specific power consumption to within 13 per cent of that of the direct-current lamp.

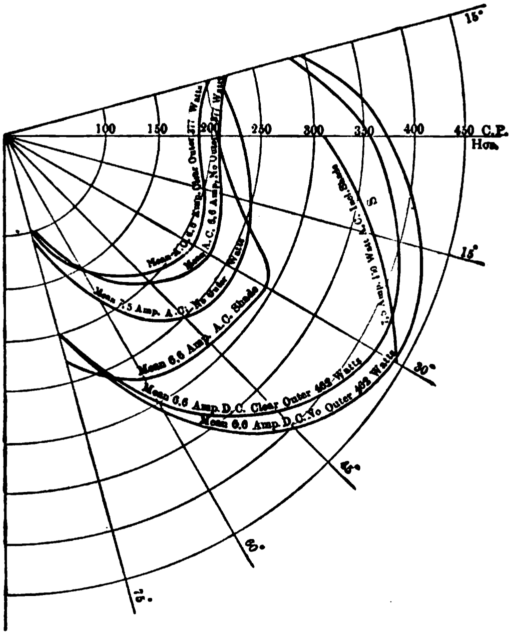

Fig. 7—The Mean Curves Taken from the Preceding Figures

Owing to lack of time, the mean hemispherical candle-power of the 7.5-ampere alternating-current lamps was not determined. Data are at hand (See Figure 7), however, to form a comparison of the specific power consumption on a basis of candle-power in the most useful directions of 0°, 15° B and 30° B. We find the watts per unit candle-power in these directions to be:

| | Horizontal | 15° | 30° |
|---|---|---|---|
| Direct-current 6.6 Clear Outer....... | 1.29 | 1.17 | 1.11 |
| Alternating-current 7.5 Shade........ | 1.45 | 1.22 | 1.02 |

### POWER FACTOR OF THE ALTERNATING-CURRENT LAMPS

The 6.6-ampere lamps show a mean power factor of .88, and the 7.5-ampere lamps of .83.

### IV. TEST OF A 450-WATT ARC UNDER VARYING CONDITIONS

Since a 2,000 nominal candle-power arc lamp is usually defined as one consuming approximately 450 watts in the arc, it becomes of much interest to see what variation is likely to exist in the lighting value of such a lamp when, the power remaining constant, such factors as current and electromotive force, nature of arc, etc., are allowed to vary within the limits that may exist in the street-lighting practice of the day. To secure a reliable result in a problem of this kind, the number of variables must be reduced to a minimum, as, otherwise, few definite conclusions can be drawn. With this idea clearly in mind, the data shown in curves and tables below were taken under the following simple conditions:

1. The use of a hand-feed arc. The lamp used was specially constructed for these tests by Mr. Hanker, and admits of a very close screw adjustment of the arc length. A sleeve arrangement surrounding the screw allows the operator to reproduce conditions closely in case of extinction of the arc. The lamp

also has a mounting for a globe when it is desired to inclose the arc. The uniformity obtainable in the photometric settings when a hand-feed arc is used in connection with the double-mirror method (See 1900 report) is quite remarkable. Frequently fifteen settings are obtained on a given arc within a range of four inches on the recording drum. This small movement of the standard means a relatively high degree of accuracy in the results.

2. The use of one pair of carbons for all of the measurements. As some of the tests were with an inclosed arc, both direct and alternating current, it was necessary to select a pair of high-grade carbons, one solid and one cored. The cored carbon was placed below. The use of a high-grade carbon for the open arc is not in conformity with usual practice, but it was deemed best not to introduce another variable by changing carbons. Similar results on open-arc carbons of the usual grades will be found further on in this report.

3. The use of the same inner opalescent globe and the same inner clear globe in all the inclosed arc tests. In this way, a fruitful source of discordant results in inclosed-arc testing was removed. For certain of the alternating arc tests a metallic street shade was used.

4. The maintenance of 450 watts in the arc as closely as possible with 9.5 amperes for the open-arcs and either 6.5 or 7.5 amperes for the inclosed.

5. The measurement of the candle power in three directions, namely, the horizontal through the arc, 15° below and 30° below the horizontal. In order that the single pair of carbons might not be wholly consumed during the tests, measurements in other directions were not attempted. It will be noted that the

angles chosen are the important ones in street lighting.

The results obtained are shown in Table XIII and Figure 8. The three candle-power values for each arc are laid off in their proper directions and the points connected by straight lines. These lines may therefore be considered as chords of the curves of candle-power distribution. The curves themselves would depart somewhat from these chords, but not sufficiently to invalidate the conclusions drawn.

Figure 8 shows at first glance that 450 watts expended between a given pair of carbon points may produce, under varying conditions such as occur in every-day practice, widely different values of candle power in useful directions. These variations depend upon whether the current be direct or alternating, the arc open or inclosed, the globe clear or opalescent, the arc shaded or otherwise, the current large or small. The power being constant, current and electromotive force vary inversely.

Considering first the direct-current arc (Lines I, II and III), we note that the 9.5-ampere arc (Line I) leads all others in candle power below 15° from the horizontal, the value at 30° B being 1,177 candle power. In this connection, it should be noted that the carbons are of the highest grade found in last year's carbon tests. In line II, we see that the reduction of the current to 6.5 amperes, with consequent lengthening of arc, and the use of a clear globe have the effect of reducing the candle power especially below 30° B. This reduction is probably due to reduced crater area caused by the lowered current density. At any rate, the conclusion is warranted that no advantage comes from the substitution of the 6.5-ampere arc with *clear* globe for the 9.5-ampere open arc, in so far as distribution of light is concerned. Passing now

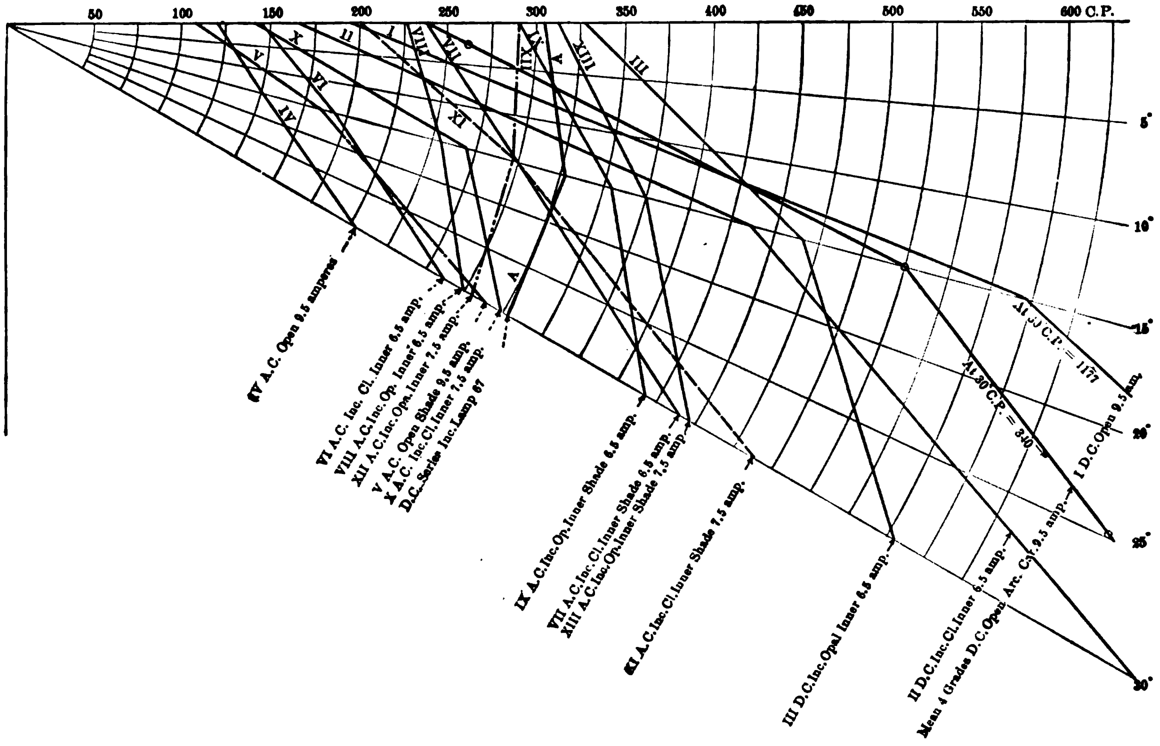

FIG. 8—TEST OF A 450-WATT ARC IN VARIOUS FORMS

to line III, which shows the effect of an opalescent globe on the 6.5-ampere arc, we find quite the opposite result. The horizontal intensity is strengthened from 195 to 328 candle power, or about 68 per cent. The inclosed arc remains superior from the horizontal down to about 12° below, in which direction the two arcs give the same luminous intensity. This means that if the two arcs were suspended at the same height, say of 25 feet, they would produce equal illumination at a distance of about 117 feet from lamps, but beyond this distance the inclosed arc would have an increasing advantage over the open as a street illuminant. It is clear from lines II and III that, in street lighting, the superior candle-power distribution of the inclosed arc is secured chiefly through the use of the opalescent inner globe. This globe becomes itself highly luminous, thus strengthening greatly the intensities near the horizontal.

Now, if we compare lines I and IV, we see the advantage possessed by the 9.5-ampere direct-current open arc over the corresponding form of alternating-current arc. The latter, of course, is but little used. When the 450-watt, 9.5-ampere alternating arc is inclosed in clear glass and the current reduced to 6.5 amperes, we find (Line VI), unlike the corresponding direct-current case, a strengthening of the candle power in all three of the angles chosen for measurements. This strengthening of candle power amounts to 20 per cent in the horizontal and somewhat more in the other two angles. If, however, the clear globe is replaced by an opalescent one—all else remaining the same — line VIII is obtained. This line is much farther out and considerably steeper than VI, hence possessing the peculiar qualities necessary to the lighting of remote points. The average per cent gain in the three angles accruing from the change from clear globe to opalescent globe is 32.

The effect on the candle power in the chosen directions of a metallic shade of the type commonly used in street lighting is shown in the case of the clear inner in line VII, which now replaces VI, and in line IX, which now replaces VIII. The general effect is what would be expected, namely, a marked gain in candle power throughout the zone in question. The gain in such cases is largely dependent on the contour of the shade and the character of its reflecting surface. Hence only very general conclusions can be drawn as to the benefit to be derived from the use of such reflectors. The extent to which the horizontal candle power is affected depends to some extent on the height at which the shade is placed above the centre of the inclosing globe.

The same shade was also placed over the 9.5-ampere open alternating arc with the result shown in line V, which should be compared with IV. The most marked gain here is at 30° B.

It is to be said that 6.6-ampere series alternating arcs in their commercial form do not consume 450 watts, whereas the 6.6-ampere arc in these tests did consume this power, the result being obtained by raising the electromotive force of the arc to 82.4 volts. This fact explains why the candle-power values in these 450-watt tests are higher than those of the lamps reported on in section II of this report.

We have now to consider the 7.5-ampere alternating arc. Comparing line X of the 7.5-ampere clear-globe arc with line VI, which shows the corresponding case for the 6.5-ampere arc, we note that no advantage is secured directly in the horizontal. However, the other two intensities are notably strengthened by the higher current density in the carbons, especially the 15° B.

When an opalescent globe is used on the 7.5-ampere arc, line XII is the result. Here we have nearly the same candle power in all three directions. This, then, is a very desirable distribution for the lighting of remote points. The use of a street shade on this lamp yields line XIII. This arc shows a candle power in directions near the horizontal nearly equal to that of the 6.6-ampere direct-current arc of the same power.

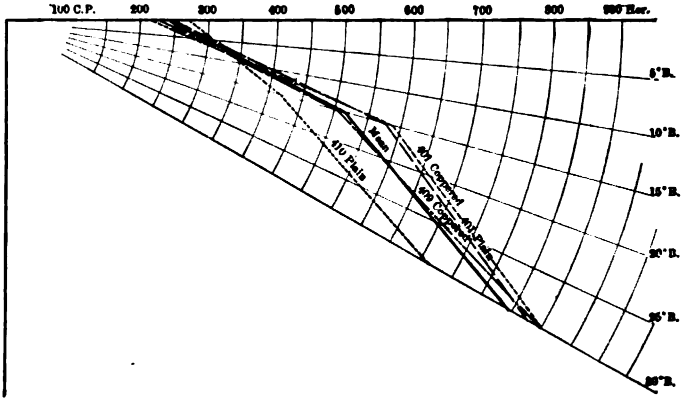

FIG. 9—CANDLE-POWER TEST OF DIFFERENT BRANDS OF OPEN-ARC CARBONS

## V. TESTS OF VARIOUS BRANDS OF HIGH AND LOW-GRADE CARBONS

The primary object of these tests is the determination of the relative candle power obtainable from high and low-grade carbons burned in a 9.5-ampere, 450-watt open arc. This portion of the work is not so exhaustive as it should be, but enough has been done to indicate something of what may be expected from tests of this character. Candle-power measurements were made in three directions, as indicated in

Figures 9 and 10. The first of these figures shows the results obtained from four different brands of open-arc carbons, together with the mean result from all four (See also Table XIV). Brand 410, a moulded carbon, is 12 per cent stronger than the mean in the horizontal, but falls behind the mean by nearly 20 per cent at 15° B. Brand 401 shows a performance almost the reverse of 410, being weak in the horizontal direction and strong in the other angles. Differences merely in the shape of the distribution lines must be attributed largely to variations in the shape of crater and point on the carbon tips. While differences in this respect were plainly noticeable, it was thought that the number of tests was insufficient to warrant any definite conclusions.

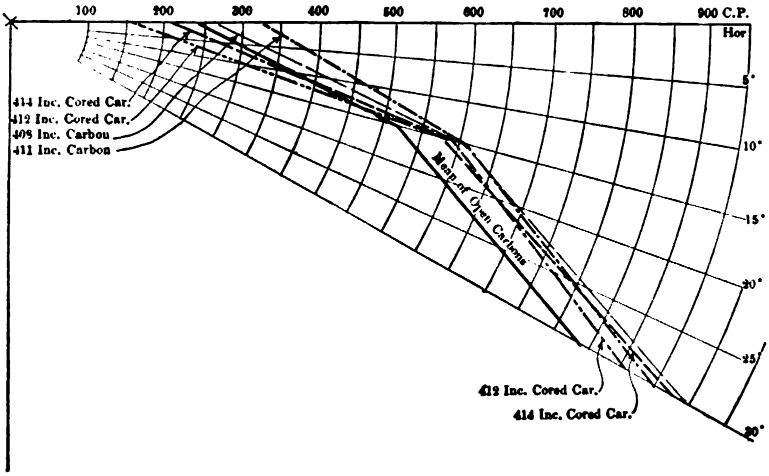

FIG. 10—CANDLE-POWER TEST OF DIFFERENT BRANDS OF HIGH-GRADE CARBONS IN AN OPEN ARC

The results of tests on high-grade carbons are shown in Figure 10. For the sake of a ready comparison, the mean line of the open-arc carbons has been trans-

# TABLE XIII

## 450-WATT ARC UNDER VARYING CONDITIONS*

| No. of Curve | Kind of Arc | Globe | E. M. F. | Current | Power Factor | Luminous Intensity | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Hor. | | 15° B. | | 30° B. | |
| | | | | | | H. U. | C. P. | H. U. | C. P. | H. U. | C. P. |
| I | D. C. Open ..... | None.......... | 47. | 9.5 | ... | 221 | 195 | 680 | 598 | 1,338 | 1,177 |
| II | D. C. Inclosed.. | Clear Inner†.... | 70. | 6.5 | ... | 187 | 165 | 495 | 436 | 838 | 738 |
| III | D. C. Inclosed.. | Op. Inner‡..... | 70. | 6.5 | ... | 373 | 328 | 528 | 465 | 658 | 579 |
| IV | A. C. Open ..... | None.......... | 49.3 | 9.5 | .96 | 137 | 120 | 171 | 150 | 261 | 230 |
| V | A. C. Open ..... | Shade......... | 49.5 | 9.5 | .96 | 122 | 107 | 210 | 185 | 358 | 315 |
| VI | A. C. Inclosed.. | Clear Inner .... | 82.4 | 6.5 | .84 | 165 | 145 | 219 | 193 | 328 | 289 |
| VII | A. C. Inclosed.. | Cl. Inner-Shade. | 82.4 | 6.5 | .84 | 269 | 238 | 340 | 300 | 499 | 439 |
| VIII | A. C. Inclosed.. | Op. Inner ...... | 82.4 | 6.5 | .84 | 257 | 226 | 290 | 255 | 340 | 300 |
| IX | A. C. Inclosed.. | Op.Inner-Shade. | 82.4 | 6.5 | .84 | 331 | 291 | 403 | 355 | 476 | 418 |
| X | A. C. Inclosed.. | Clear Inner..... | 70.7 | 7.5 | .85 | 159 | 141 | 307 | 270 | 368 | 324 |
| XI | A. C. Inclosed.. | Cl. Inner-Shade. | 70.7 | 7.5 | .85 | 227 | 200 | 342 | 301 | 554 | 488 |
| XII | A. C. Inclosed.. | Op. Inner...... | 70.7 | 7.5 | .85 | 329 | 290 | 339 | 298 | 347 | 305 |
| XIII | A. C. Inclosed.. | Op.Inner-Shade. | 70.7 | 7.5 | .85 | 355 | 312 | 425 | 375 | 506 | 445 |

* The same pair of carbons used throughout the tests; namely, ½" carbons for inclosed arc. Solid upper. Cored lower.

† The same clear inner globe used throughout the tests.

‡ The same opalescent inner globe used throughout the tests.

# TABLE XIV

## CARBON TESTS

| Carbons | Luminous Intensity | | | | | | Life in Hours per Inch* | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Hor. | | 15° B. | | 30° B. | | | | |
| | H. U. | C. P. | H. U. | C. P. | H. U. | C. P. | + | — | |
| 401 Plain.......... | 279 | 246 | 653 | 575 | 993 | 877 | .94 | 1.33 | Good Arc |
| 401 Coppered...... | 246 | 216 | 659 | 580 | 1,023 | 900 | .92 | 1.35 | Some Flickering |
| 409 Coppered. .... | 259 | 229 | 571 | 503 | 1,013 | 891 | .79 | 1.20 | Slightly Sputtering |
| 410 Plain.......... | 302 | 266 | 472 | 415 | 810 | 713 | .92 | 1.49 | Good Arc |
| 408 Inc. Carbon..... | 297 | 261 | 688 | 605 | 1,132 | 997 | .84 | 1.32 | Some Flickering |
| 411 Inc. Carbon.... | 368 | 324 | 690 | 607 | 1,085 | 955 | .80 | 1.32 | Steady Arc |
| 412 Inc. Cored Car.. | 184 | 162 | 666 | 586 | 1,035 | 911 | ... | .... | Good Arc |
| 414 Inc. Cored Car.. | 237 | 209 | 654 | 576 | 1,095 | 964 | ... | .... | Good Arc |
| 407 Plain .......... | ... | ... | ... | ... | ..... | ... | .94 | 1.42 | |

Intensity tests of above were run in hand-fed lamps. Life tests in open-arc lamps 301, 302, 303.

* Mean of three tests.

ferred to this figure. It will be seen that the carbons of high grade when solid give more candle power in all three directions. When cored, they fall behind the mean of the low-grade carbons throughout the angle between 0° and 12° B. This is, without doubt, due to the deep crater formed in the cored carbon.

Six brands of these carbons were tested for life in ordinary series arc lamps. The results are to be found in Table XIV, where the figures show the mean result obtained from three sample pairs in hours per inch. Although high-grade carbons give a superior candle power, they show a somewhat shorter life when burned open than the low-grade. Thus the mean life of the positive low-grade carbons is about 9 per cent greater than the high-grade. The difference in the life of the negatives is slight. The "range" or difference between the hissing and flaming voltages was not determined for these carbons. This, however, is an important matter, as the able paper of L. B. Marks in the 1895 proceedings of this association makes clear.

## VI. CURVES OF ILLUMINATION

Curves showing the distribution of candle power such as those in the early part of this report are valuable, because they tell us not only the total useful flux of light, but also the distribution thereof, so that we are able to predict the relative value of the illuminant for any particular kind of service. However, this latter quality is possessed in a higher degree by a curve readily derived from the candle-power curve and known as the illumination curve. The illumination curve is one whose abscissæ are distances along the street surface, and whose ordinates

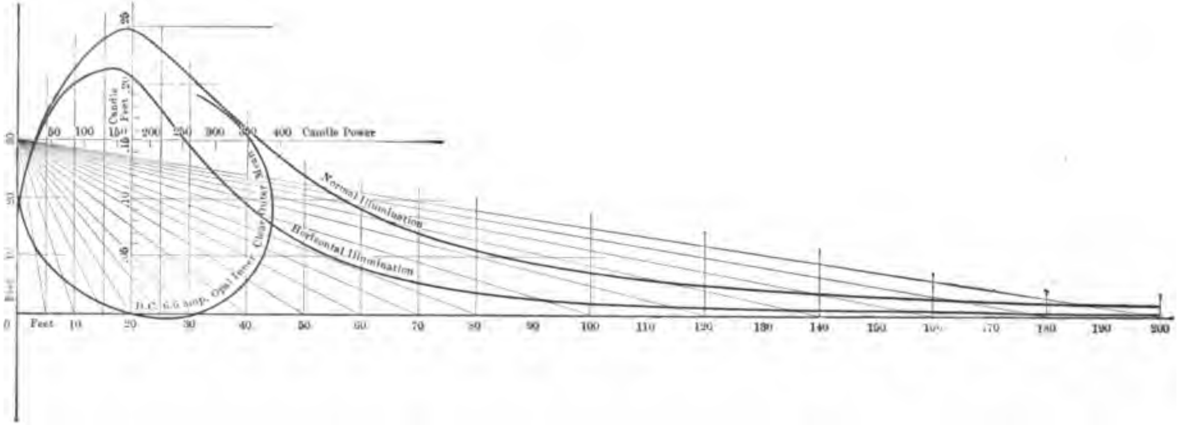

FIG. 11 — CURVES TO SHOW THE DIFFERENCE BETWEEN "NORMAL" AND "HORIZONTAL" ILLUMINATION. (6.6-AMPERE, DIRECT-CURRENT LAMP, OPALESCENT INNER, CLEAR OUTER. SEE FIG. 1)

are found by dividing the candle-power in each direction by the square of the distance in that direction from source to street. For example, the ray striking the ground at a point 40 feet from a point directly underneath the lamp has an intensity of 400 candle power; the slant distance from arc to street is 50 feet; hence the illumination is $\frac{400}{2500}$, or .16 candle foot; that is, equal to the illumination produced by .16 candle at a distance of one foot. This is the illumination on a plane normal to the ray. As many writers multiply this illumination by the sine of the angle between the ray and the horizontal to obtain what is known as the *horizontal* illumination, it has seemed well to show clearly the difference between the two magnitudes. Thus, in Figure 11, the upper curve is the *normal*, the lower the *horizontal* illumination. At a point directly beneath the source, the two are equal, but at all other points the horizontal illumination is less than the normal. In what follows, we shall consider only the normal illuminations since it involves a simpler conception. It may be said in passing that the other is often the useful magnitude. For example, when several sources contribute to the illumination of a point, the horizontal value is the only practical basis of comparison.

Figure 11 shows that a 6.6-ampere direct-current lamp placed 30 feet above the street yields an illumination varying from a maximum of .25 candle foot at 20 feet to .01 candle foot at 200 feet; that is, in the ratio of 25.1.

## EFFECT OF HEIGHT OF LAMP

The illumination in the immediate vicinity of the lamp will be found to vary rapidly with any change in the height of the lamp, but as this illumination will always be ample at any practicable height, we may well disregard it and consider only the flatter

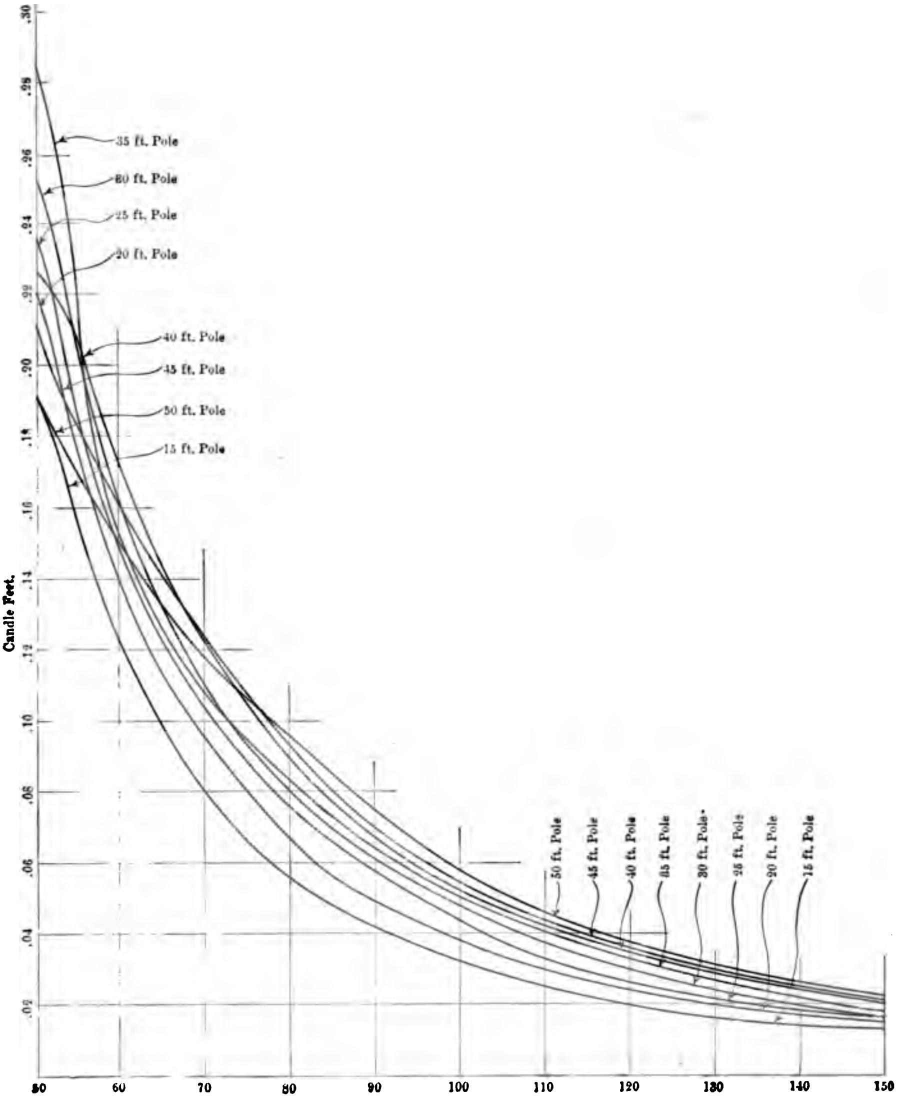

FIG. 12—EFFECT OF VARYING THE HEIGHT OF AN OPEN-ARC LAMP

portion of the curve, say from 50 to 150 feet from a point underneath the lamp.

Figure 12 shows the change that occurs in the illumination at different points when an open arc is

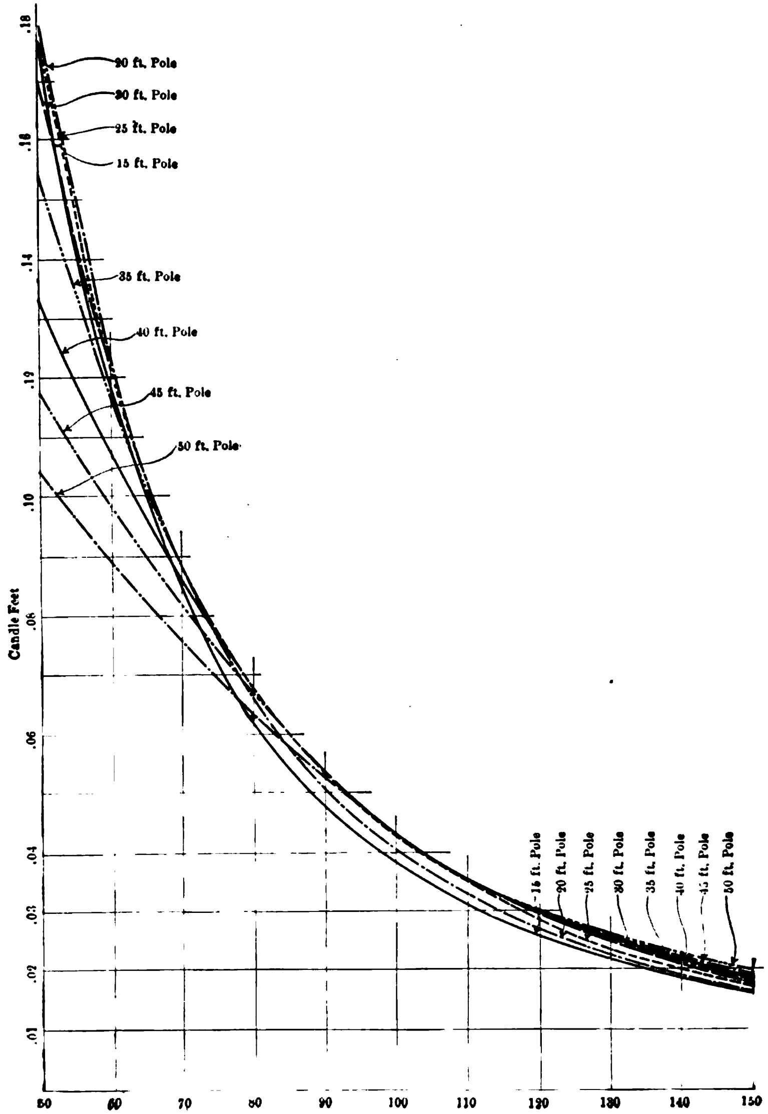

FIG. 13—EFFECT OF VARYING THE HEIGHT OF AN INCLOSED-ARC LAMP

raised from 15 to 50 feet. The illumination increases at points lying between 80 and 150 feet. At points lying between 50 and 80 feet, .there is an increase until a height of 40 feet is reached, and then there begins a decrease. Continued increase in the height would, of course, diminish the illumination at the more remote points. Where the foliage of trees does not interfere, there is a manifest advantage in placing the open arc at a good height. Attention should be called to the fact that the candle-power curve from which these illumination curves have been derived is that marked o in Figure 8. This curve is the mean result of the open-arc carbon tests.

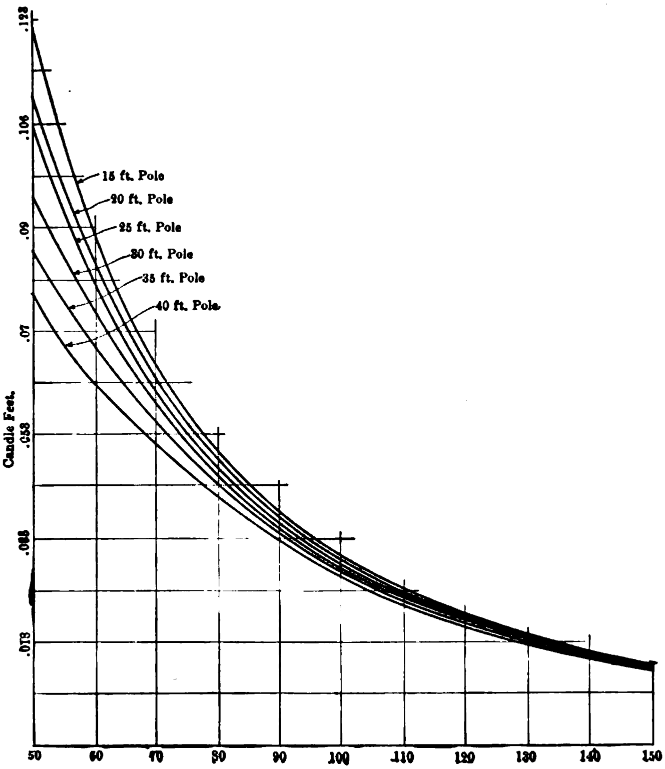

FIG. 14—EFFECT OF VARYING THE HEIGHT OF AN INCLOSED ARC. SECOND CASE

The effect of varying the height of a direct-current 6.6-ampere inclosed arc is shown in Figure 13. We note similar changes in this case. However, the change in the illumination at 150 feet is less than in the case of the open arc. Moreover, the illumination in the vicinity of 50 feet begins to fall if a height of 30 feet is exceeded. Now, whether a lamp will show an increasing or decreasing illumination through this range of height depends upon the shape of its candle-power curves throughout what we have considered in this report as the important zone. That an inclosed arc may show a change in illumination quite the reverse of the foregoing is shown in Figure 14. This lamp has a very steep candle-power curve near the horizontal. (See line A, Figure 8.) As a result of this feature, raising the lamp from 15 to 40 feet steadily lessens the illumination at all points between 50 and 150 feet. It is worthy of note that the illumination at 150 feet is practically independent

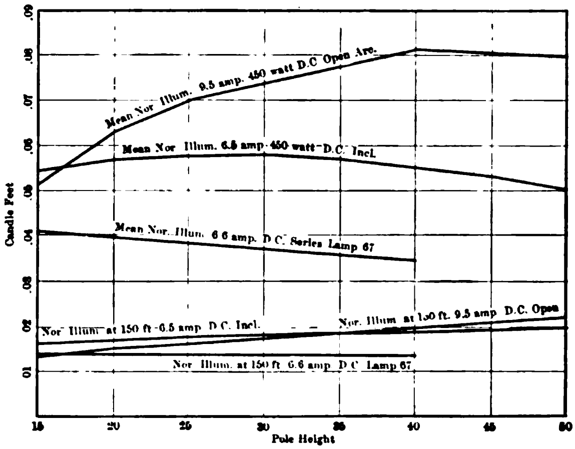

FIG. 15—MEAN AND MINIMUM (150-FOOT) ILLUMINATION AS A FUNCTION OF HEIGHT OF LAMP

of change in height of lamp through the range considered.

In Figure 15, the results of plotting the mean illumination between 50 and 150 feet against height of lamp are shown. We note that 40 feet for the open arc produces the greatest *mean* illumination. The results for the inclosed arc are contradictory, as already explained. The maximum occurs for the upper curve between 25 and 30 feet. And probably this height is the most effective under average conditions when maximum mean illumination is desired.

In conclusion, I take pleasure in acknowledging the active assistance and co-operation in this work of Mr. C. R. Dooley, assistant in the School of Electrical Engineering of Purdue University, and of Messrs. F. C. Hanker, W. T. Berkshire and M. A. Call, members of the graduating class.

Respectfully submitted,

C. P. MATTHEWS.

## APPENDIX

By kind permission, I quote from a letter bearing date of April 29th, and written by S. W. Stratton, Director of the National Bureau of Standards, Washington, D. C.

"In regard to your inquiry as to the best primary photometric standard in existence, we would unhesitatingly say that the Hefner lamp is almost universally recognized as being the best. The relation, 1 Hefner unit = .88 British candle, may be regarded as sufficiently exact, in view of the great differences obtained for this ratio by different observers, these discrepancies being always traceable to the impossibility of accurately defining the British standard candle in such a way that the result obtained will always be the same."

## DISCUSSION

PROFESSOR MATTHEWS: Inasmuch as certain parts of the work of previous years have been criticized for one reason or another, I wish to add that the aim I have had in view all the time has been to get at the truth. I think those who have been disappointed in our work have been disappointed because the values have not been shown to be larger. We see here a remnant of the old 2,000-cp idea. I feel confident that the results are more accurate than those of any other arc-light investigation that has been undertaken; in this country, at least.

THE PRESIDENT: I was appointed chairman of this committee, but during the last year and a half the work has devolved entirely upon Professor Matthews and Professor Goldsborough. I feel that they have done excellent work for the association and something of immense value to the entire electrical fraternity. I do not think the work should be stopped here, but should be carried on. I think the committee has now reached the point where valuable deductions and conclusions can be made. One point alone brought out in this report has justified the support the association has given this committee, by determining the proper height for hanging any certain arc lamp. I have not had a chance to confer with Professor Matthews since he came to the convention, and am sorry to hear him say that this report closes his connection with the arc-lamp work. If it closes his connection with the work, it probably means that the work will be stopped; or, at least, it means that the other two members of the committee are not so situated that they can do any further work along these lines. They could take these old reports and make some valuable deductions from them; but for them to undertake further research and experimental work would be impossible, I am sure.

There has always been more or less criticism of the work of this arc-lamp committee; in other words, I am sorry to say, many of our members were not looking for the truth in arc-lamp photometry, but were looking for inflated values. I do not think there is any reason why we should try to give the arc lamp a greater value than it possesses, as we are competing with a more profitable branch of our business—incandescent lighting. We want to know the true value of the arc light as compared with the incandescent. We need not fear loss of business by making known the true value of arc lamps, as there is not a central station represented in this association—no matter how active the competition may be from other sources of illumination—but could do twice as much business as it is doing to-day. I dare say there is not a member represented here who has an income to exceed three dollars per capita for lighting alone, with the exception of New York city, but we know from statistics that some stations have gone over six dollars per capita for lighting. I dislike to see this work abandoned. There is much further work, especially the relationship between incandescent and arc lights, which I hope to see brought out in future reports. There is also work that I desire to see brought out regarding the relationship between oxide-filament lamps and arc lamps. The matter is entirely in the hands of this convention as to whether it wishes to continue this work—or, rather, attempt to continue it—and whether we can prevail upon Professor Matthews to keep up the work. The criticisms have been hard to answer, but they all point in the aggregate to the fact that the arc lamp was losing the value that it was supposed to possess before this investigation started.

I am just making a very careful determination of how best to light the streets of a certain city. With the same expenditure of money I can give them a minimum illumination of nearly ten times as much with parallel-connected incandescent lamps as I can with open-arc lamps.

We have tried to carry out the suggestions we received from members from time to time, but some of the suggestions have been impossible—more than impracticable—at the stage at which we had to start in to work. There were no values determined that we could accept, and up to date the work carried on has been very unsatisfactory, being largely in the nature of research, and not in the nature of practical work. The matter is in shape now to make real and practical use of a resumé of the reports and deductions gained by the experimental work done by Professor Matthews and his assistants. I desire to call your attention to these matters, and the subject is now open for discussion.

MR. L. B. MARKS: The report read by Professor Matthews fairly bristles with facts of special interest to central-station men. To my mind, one of the most interesting sections of the report is that relating to tests of a 450-watt arc lamp under varying conditions. These tests show the relative light-giving values of practically all the types of open and inclosed-arc lamps. The results prove quite conclusively the superiority of opalescent inner globes over clear inner globes for street lighting. This superiority is due to the better distribution of light given by a diffusing globe. An objection that has often been raised against the inclosed-arc lamp is that the light given out is cut down by the absorption incident to the use of double globes. While this is true, generally speaking, Professor Matthews calls attention to the case of an alternating-current, inclosed-arc lamp in which the amount of light given out below the horizontal is actually greater with two globes on the lamp than with one. In the case in point, the outer globe (clear glass) acts like a reflector, thus increasing the mean hemispherical candle power over that obtained with the single globe. Another point to which attention is called is the superior distribution of light obtained by lamps equipped with "continuous" or closed-base inner globes. The contour of the globe undoubtedly accounts for this. It is interesting to know, also, that the mean hemispherical candle power of the 6.6-ampere, alternating-current, inclosed-arc lamp, fitted with a suitable reflector, is almost as large as that of the 6.6-ampere, direct-current arc. This bodes well for the extended introduction of alternating-current, series inclosed arcs.

The concluding chapter of the paper treats of the relation between distribution of light and the height of the lamp above the street level. Professor Matthews finds that the greatest mean illumination obtained from the open arc tested is produced when the lamp is about 40 feet above the ground, as contrasted with from 25 to 30 feet for the enclosed arc. If the mean illumination were the only thing to be considered, these figures might serve as useful standards. But in commercial practice, especially with reference to the open arc, the most desirable height of the lamp above the ground will be found to be considerably less than that required to give the greatest mean illumination.

THE PRESIDENT: Has any other gentleman any views to express in regard to the work of the Committee on Photometric Values of Arc Lamps? If there are no further remarks on this report, we will take up the subject of long-distance transmission lines, unless Dr. Perrine wishes it taken up at some other time. We have an engagement to go to the Bullock Electric Manufacturing Company's works, leaving the depot across the street at four o'clock. That leaves about thirty minutes at our disposal.

PROFESSOR GOLDSBOROUGH: Mr. President, may I present one matter before the association?

THE PRESIDENT: Yes, sir.

PROFESSOR GOLDSBOROUGH: I am commissioned by the president and board of directors of the Louisiana Purchase Exposition Company, in connection with the world's fair to be held in St. Louis, Missouri, in 1904, to extend to the National Electric Light Association a hearty and cordial invitation to hold its twenty-seventh convention on the exposition grounds. The exposition authorities also ask your co-operation, if you are willing to extend it to them, in the development of a thoroughly representative electrical display, one that will do much to demonstrate broadly the numerous and various applications of electricity and help to extend the use of electricity in the industries.

You may know that the directors of the exposition are attempting to do at St. Louis something that will be on a larger and grander scale than anything ever accomplished in the history of international expositions. They have, altogether, $17,000,000 contributed toward the building up of the exposition, on which they will have to make no return. The St. Louis exposition is, therefore, in far better position than any previous exposition has been to do something that is grand, and much energy is being expended to bring this about. The Electricity Building will be a large structure, 600 feet either way, and will equal in area four city blocks. The exposition company has not been mean in setting apart a substantial space for exploiting electricity.

I am more or less convinced—and the idea seems to be quite prevalent—that electricity has reached the point where it can be regarded as only one of the forms of energy upon which we are dependent, and we naturally expect that when future expositions are held electricity will hardly be accorded a special place. It will be catalogued as are other forms of energy; in the same way as gas, steam, water, etc. Thus we now have an opportunity to show the final outcome of the energy and skill that has been expended in developing electricity. I hope that with the co-operation of the electrical fraternity it will be possible for us to do something commensurate with our ideas of what electricity means to the world.

MR. AYER: Mr. President and gentlemen: I hardly think that we need spend any time in discussing a motion to accept the invitation of the Louisiana Purchase Exposition Company, to hold our meeting at St. Louis in 1904, because it is apparent that all organizations of this character will find it greatly to their advantage to hold their meetings at the exposition. This exposition will undoubtedly be larger than any we have ever had in this country, and, without taking your time further in the matter, I desire to offer the following resolution:

*Resolved*, That in 1904 the annual meeting of this association be held on the grounds of the St. Louis exposition company, at St. Louis, Missouri, and that the association lend its best endeavors to contribute to the achievement of such an electrical exhibition as the considerations of the exposition management (as indicated by their generous provisions) and the industry demand.

MR. GILLETTE: I second Mr. Ayer's resolution.

(The resolution was unanimously adopted.)

THE PRESIDENT: There will be an executive session of this body at half after seven o'clock this evening. After our executive session we will take up two papers on decorative lighting and its importance. Every active member should be in this room promptly at half after seven, as there will be important matters taken up.

We will now take up the consideration of the papers on "Protection of Long-Distance Transmission Lines."

# PROTECTION OF LONG DISTANCE TRANSMISSION LINES

## CHARLES H. BAKER

The chief weakness in a transmission project is the transmission line itself. Although every precaution has been taken, and no expense spared in constructing well this artery between the generating point and the consumer, yet nearly all our troubles have centered here.

Our line travels mostly through a densely-timbered region and we have consequently had to go to great expense in eliminating the dangers from falling trees and falling branches, by cutting through the forest a swath of varying widths according to the height of the timber, in some places the belt cleared reaching 600 feet wide. The felling of the trees does not alone suffice, but they must be burned up and the débris cleared off in order to remove the danger of running fires in the dry summer weather.

As a further protection against fires, and against the growth of brush and second-growth timber, which will interfere with the protection of the wires, we have, immediately upon clearing the right of way, sowed the same its entire length with white clover seed. White clover is indigenous to the soil in this country, whether in valleys or on hill tops, and we have therefore produced a fine turf which effectually corrects the dangers most feared.

We do not think a transmission system can be entirely reliable without a double circuit. Our present system transmits from the generating point at 30,000 volts by two circuits, each to Seattle, and two circuits each to Tacoma. These circuits parallel each other for twenty miles, and at the twenty-mile point they are interchangeable through a high-tension plug-board system. For this twenty miles we therefore have more assurance of continuity of service than from this point to the terminals where only two circuits cover.

It is our purpose later on, and we think it a good plan, to put in a plug board at one or two other intermediate points, in order to be able further to divide or interchange the circuits. If there is a break on any circuit, it can, by means of these plug boards be located on a parallel short division and the circuit in trouble can be cut out and repaired.

It has been our practice to repair a circuit in trouble while current was running on the other circuit on the same sets of poles. An operation of this sort, however, must be undertaken by only skilful and cool-headed men. Our wires are spaced thirty inches apart in the triangle.

About every fifth pole has a spare cross arm tacked upon it, and every half mile there is a spare pole resting on skids. The location of these spare cross arms and poles is known by the number of the pole at which they are located, and the patrolmen have a record of these, so that if there is any trouble he knows at once where to go for relief material.

Every three miles on our transmission we have a telephone booth located, which is commodious enough to contain also a few insulators, pins, wire, etc. The patrolman in making his rounds enters the booth and reports by telephone his presence there to the head works office at Snoqualmie Falls, and he also registers his call in the booth, so that his visits may be tallied at any time by the general superintendent or inspector. He reports the line "O. K." when he gets to the booth, if such be the case. The length of the section in charge of each of our patrolmen varies with the character of the country and the difficulty of traveling it, but in general one man has about twenty miles in charge and patrols it twice a week. After having made a tour of inspection the patrolman mails a report card to the Seattle office, certifying the condition of the line.

Built as our line is, and inspected as rigidly as it is, we have eliminated entirely all troubles due to falling trees, running fires or wind storms. In fact, our troubles narrow down entirely to those due to interference evidenced either by malicious persons or boys shooting off insulators or throwing wires over the transmission lines.. The only remedy for this is to make an example of a guilty party, and the experience of other transmission concerns has shown that such an example puts a quietus on the interference. We have had a law enacted in the legislature of this state, making any such interference a penitentiary offense, but thus far we have been unable to convict anyone.

In addition to the private telephone system following our transmission, we have our various stations connected in with the general commercial system, which we use in emergency cases only where our telephone system is incapacitated.

As soon as a short circuit occurs, the lines are tested out immediately, to find out on what section the trouble lies. The trouble is invariably on one circuit only, so that the entire load is immediately placed upon the other circuit pending the correction of the trouble. As soon as the trouble is located on a division, the patrolmen from each end of that division start towards each other in great haste to reach it and repair it.

Our apparatus is protected by lightning arresters installed on the main circuits at the primary station and each of the substations. We have very little lightning in this country and only once, I believe, in three years, have these arresters actually been called to duty, and on this occasion they worked to perfection.

All our circuits are fused at the different stations for 100 per cent overload, so that in case of a dangerous short circuit coming in, the fuses open up and the apparatus is cut out.

As an improvement upon our own practice, and to make the protection of any long-distance system further assured, I would suggest that the triangle of wires be constructed so that the apex insulator will be below instead of above, for the reason that a wire—or anything thrown over the lines—will be less likely, under such an arrangement, to cross two wires. In our system the apex is above. I would further suggest that the spacing in the triangle be greater for the same purpose, even though the inductive drop is thereby increased somewhat. Spacing should be at least 36 inches.

The insulator is the strong or weak point in a transmission system, and I am glad to say that we have been very successful, using the Porcelain Imperial Insulators, of the best quality. I would suggest, however that the insulators receive a brown glaze instead of the white (as in our case) as they will thus present a poorer target for anyone aiming at them. We have had a great many insulators broken to the extent of the petticoats being shattered off, but the wire almost invariably remains upon the core of the insulator. This would not be true in the case of a glass insulator, which would be shattered to pieces, allowing the wire to come down upon the cross arm.

I would suggest, further, that the telephone system be maintained upon a separate set of poles, as trouble on the transmission line is very sure to put the telephone out of service if both are on the same poles.

These suggestions we would certainly inaugurate in any new lines that we are to build. As it is, any interruptions we have, and they have now been reduced to a minimum, seldom last over three to six minutes, which is just long enough to test out the line and switch the load on to the circuit which is intact. The location of and repair of the break, of course, takes longer, depending upon the distance the patrolmen have to go to reach it, but the repair of this, as stated above, does not interfere with the service.

## L. DENIS

The Quebec-Jacques Cartier Electric Company has thus far had little experience with lightning trouble. Our transmission line consists of two three-phase 23,000-volt lines, some eighteen miles in length, and in several places passing in the neighborhood of tall trees. It is protected at both ends, at the very points where the wires enter buildings, with sets of Wurts lightning arresters arranged in the standard Westinghouse fashion. These arresters are our only protection against lightning. Although they have been noticed to spark occasionally, we have never experienced more than the result of a partial short circuit from the discharge. We seem to have had more trouble from gradual discharges, and from induced charges that take effect on the low-tension side of our station transformers. On one occasion, one of these charges caused quite an amount of damage on the 2,000-volt switchboard, arcing to the ground from terminals leading to current transformers. In this case, as in others of the same nature, but less serious, apparently no damage was done to our station transformers.

We may add, for the sake of information, that this locality has quite a reputation for the severity of its lightning storms.

## P. N. NUNN

We have, at our several stations in Colorado, Utah and Montana, a number of lightning-arrester installations. These installations are all of the Wurts type of non-arcing arrester, and consist of a number of paths to ground, with a number of choke-coils between the line and apparatus to be protected. The exact arrangements employed are various and for voltages ranging from 4,000 to 60,000 volts, the higher voltage being, in general, from star-connected transformers with neutral point grounded.

In all of these various installations an attempt has been made to improve upon the previous practice, and, in general, this has been successful. We have never had a serious disaster caused by lightning, or by the violent oscillations caused by the opening and closing of long power lines of large capacity and at a very high potential.

We have, however, had numerous small annoyances caused by lightning and the oscillations above referred to, and for this reason do not regard our present lightning protection as entirely satisfactory. For this reason we are now experimenting with the more recent type of arrester installation, including shunted and series resistances and fewer paths to ground. This work has not passed beyond the first experimental stage and we have no data to offer on it at present.

Lack of time prevents me from going into the details of the numerous experiences with lightning protection for high-potential circuits roughly summarized above.

I trust that this brief statement of our situation with regard to lightning protection may be acceptable to you, and regret it is impossible for me to go further into the matter at present.

## HENRY J. GILLE

The St. Croix Power Company is operating a 25,000-volt transmission line approximately thirty miles long, from Apple River Falls, Wisconsin, to St. Paul, Minnesota.

At the power house at Apple River Falls are installed four 750-kilowatt, 60-cycle 300-rpm., General Electric 800-volt revolving-armature generators. These generators are direct-connected to Victor turbines, each set consisting of two 36-inch special wheels, the working head of the water being 82 feet.

The governors used are of the improved Giesler pattern and guaranteed to maintain the speed of the wheels within three per cent for any change of load not over 25 per cent of the total load at the moment of variation. The governors are electrically controlled, the necessary current being furnished by the exciters.

The step-up transformers are six in number, 500 kilowatts each, being of the air-blast type, connected in two banks of three each, the high-tension side being connected in Y, the centre of the Y not grounded.

The transmission line consists of two three-wire circuits on one line of poles. The poles are spaced at a maximum distance of 110 feet. The size of wire is Number 2 B & S medium drawn copper, one circuit being supported on each side of the poles on two cross-arms in the form of an equilateral triangle with 24-inch sides. One of these circuits runs straight through without transposition, while the other is spiraled twice at equal intervals.

At each end of the line is located a lightning-arrester house. The lightning-arrester house at the St. Paul end is within two miles of the sub-station and is also used as a cable-terminal house. At each end of the line is a choke coil on each wire and twelve 2,000-volt lightning arresters. Each arrester has four air gaps of about one-eighth inch each; cylinders being one inch by an inch and a quarter in series with two graphite resistances, each having a cold resistance approximately of 450 ohms.

From the cable-terminal house the current is carried underground through cables at the line voltage to the sub-station. The cables are two in number; one insulated with rubber and the other with prepared paper, both being lead covered, and each of sufficient capacity to carry the entire load. In both cables there are three conductors, each conductor consisting of seven strands of copper wire.

At the sub-station in St. Paul there are cable terminals, switching devices and static arresters. The static arresters are lightning arresters, the same as described above, and are connected the same as lightning arresters except that the center of the Y is not grounded.

The equipment in the sub-station consists of six 300-kilowatt step-down transformers, four 200-kilowatt step-down transformers, and six 250-kilowatt each, 600 rpm., 60-cycle synchronous converters running self excited. The six 300-kilowatt each static step-down transformers are connected in two banks of three each, stepping down from 21,500 volts three-phase to 85-volts six-phase. These transformers are used in connection with the synchronous convertors which supply the Edison three-wire system, the neutral of which is grounded. The four 200-kilowatt transformers are used to step down from 21,500 volts to 2,200 volts to supply the alternating-current distribution system.

In the sub-station is also installed a storage battery with a capacity of 2,000 amperes for three hours, being 1,000 amperes for three hours per side.

All feeders from the sub-station are underground.

During electrical storms the line is almost always affected in some way, sometimes very slightly and sometimes shutting the system down entirely. When the storm is severe we usually observe a discharge on one leg of the arresters. The discharge affects the generators at the power house practically the same as does a heavy short circuit and there seems to be a strong tendency for part of the generators to motorize, and always slow down. In some cases they have come practically to a stand still. We have had several cases where the lightning has apparently disregarded the choke coils and the lightning arresters, and damaged the static transformers.

At the sub-station the synchronous converters slow down, but apparently remain in step until the fields become practically dead. This occurs in about ten seconds. When the generators begin to pick up again at the power house the rotaries also come up with considerable flashing at the brushes. Sometimes they come up with the polarity on part of the rotaries reversed. If they all come up right side up they pick up the load and carry it along as if nothing had happened, but if part of them come up wrong side up it is necessary to shut down and change the polarity.

The alternating-current system is not so easily affected as is the direct-current system. When the transmission line is affected by lightning discharge and the current comes back in the sub-station, the circuit breakers on the alternating-current feeders usually open up, especially on feeders where there are induction motors. This is without doubt due to the fact that the induction motors will take considerably more current to bring them to speed again than is required when they are up to speed; that being practically the only time when all the induction motors on the circuit are started at the same time, these circuit breakers therefore open up, due to a heavy overload.

The effect on the line is entirely dependent upon the severity of the electrical storm. If the electrical disturbance of the atmosphere is light, the lights in the city merely wink. Under these conditions the apparatus does not seem to be affected, but when the electrical disturbances in the atmosphere are very severe it is very difficult to keep the rotary converters in service, due to the fact, as explained above, that when they slow down some of them come up reversed, thus shutting down the whole system; or if they come up right side up, they have to pick up the load at zero, which puts a very heavy overload on them for a short time. This is liable to blow the alternating-current fuses and motorize the rotaries.

There is evidence on a great many poles on the transmission line of discharges jumping from the wire to the poles. We have not had poles so badly damaged that they have had to be replaced, but some of them were badly split. At the time of these discharges the insulators on the line were apparently not affected; as a matter of fact, we have had no insulators broken through lightning discharge.

The lightning arresters and static arresters are so adjusted that they discharge constantly, the discharge being very light, being visible only on two or three air gaps next to the line wire. The lightning arresters at one end of the line were very badly damaged during one storm last summer, when the discharge apparently jumped from the line to the ground, arcing across the cylinders without regard to the resistances, forming a straight path to the ground. How long this arc was held we do not know; however, it held long enough to do considerable damage to the cylinders and porcelain.

I hope that in the discussion in regard to lightning troubles on long-distance transmission lines there will be some remedy suggested which will overcome the troubles which I understand, through extensive correspondence with transmission companies, are pretty general. The trouble where no synchronous apparatus is used is not regarded as so serious, but all the companies that I have been referred to by manufacturers, who are operating synchronous apparatus, state that they have considerable trouble during electrical storms.

### P. M. LINCOLN

The effects of lightning on the Niagara Falls-Buffalo transmission line may, for the purposes of discussion, be divided into two classes: (1) Those lightning discharges which cause destruction of apparatus attached to the transmission line; and (2) Those discharges which cause a general short-circuit, but without the destruction of any apparatus.

So far as destruction of apparatus is concerned, the Niagara-Buffalo line has been peculiarly fortunate. During the five and one-half years of its operation, practically the only apparatus that has ever been destroyed by lightning has been lightning arresters. The exception of any importance to this statement was the short-circuiting of a 500-kilowatt transformer on one occasion at Tonawanda—about half way between Niagara Falls and Buffalo. The only other exceptions consist of one ammeter transformer and a few ground detectors.

In the matter of lightning arresters, however, the line has not been so fortunate. Several different styles and makes have been installed and tried with the result of ultimate disaster to the arrester. Failure has been due to the inability of the arrester to interrupt properly the dynamo current that follows the discharge, and the resulting short-circuit at the arrester would usually put it out of business, at least temporarily, and occasionally, permanently. The conditions at Niagara are, of course, unusually severe. The low frequency and the large amount of power involved make it difficult to interrupt a short-circuit when once started. Devices that work perfectly on higher frequencies and with less power back of them, have failed utterly on the Niagara-Buffalo line. One of the things which I consider that the experiences of this line have proven is that it is absolutely necessary to limit, by means of resistance, the dynamo current which flows on the discharge of the arrester. No matter what the number of gaps through which the discharge takes place, an arc once started seems to be maintained unless the dynamo current is thus limited.

The device that comes nearest answering our lightning-arrester problem is the one now in operation; that is, the so-called "Low Equivalent" lightning arrester manufactured and installed by the Westinghouse Electric and Manufacturing Co. In that device the gaps have an ohmic resistance in series with them and another larger resistance in shunt to a portion of the gaps. This arrangement gives the line-discharging effect of the small series resistance and the current-interrupting effect of the combined series and shunt resistances. In their original form these were put into operation in the summer of 1899, and are still in use in a somewhat modified form. Our former experience, however, has led to the adoption of fuses in the discharge circuit, so that in the case of a short-circuit taking place in the arresters, both line and arresters are protected; the line from a continuation of the short-circuit, and the arresters from the damage that would necessarily follow that continuation. In all our lightning arresters, choke coils are put in the line and the discharge circuits tapped on the line side of the choke coils.

In the invitation to present these notes, the question is asked, "How frequently are your lines affected by lightning that your devices have failed to arrest?" Those occasions when the arrester conducts off the flash, but becomes short-circuited, can hardly be called failures to arrest. It is possible—and perhaps even probable—that other apparatus might have been destroyed had not the flash been taken care of by the arrester. In most of the failures to arrest, as observed on the Niagara-Buffalo line, the lightning has caused short-circuits somewhere along the overhead line, some.

times with a simultaneous discharge across the gaps of the arrester and sometimes with no sign of such discharge. Our observations would indicate that the voltage necessary to jump over a wet insulator does not differ greatly from that required to jump across the gaps of the lightning arrester. In case such a short-circuit is once established anywhere along the line, it almost always continues until the current is pulled off the lines, in spite of the fact that the distance between our conductors is 36 inches. Most of our lightning interruptions are of this nature. No permanent damage is done. All that is necessary is to take off the current for an instant; supply of power can be resumed immediately.

An examination of the records for the past three summers—those of 1899, 1900 and 1901—shows that during that time eighteen interruptions occurred due to lightning, five of which occurred within a space of about three hours, during a storm of unprecedented severity. The average duration of the interruptions has been about four minutes. Considering the prevalence of lightning on the Niagara Frontier, I consider this record a very good one.

These remarks are not by any means intended to cover the subject under discussion, but are simply in the nature of brief notes, which may be of interest to the association.

### NORMAN T. WILCOX

The Colorado Electric Power Company's generating station at Cañon City, Colorado, generates three-phase current at 30 cycles and 500 volts. This current is stepped up to 22,000 volts by means of three 400-kw transformers connected in delta. These transformers have 1,000 kilowatts in steam-driven generators to supply the current to be transmitted to the Cripple Creek Mining District in the Pike's Peak region, 25 miles distant, by means of a single transmission line with but one set of conductors. This line passes through a rugged mountain country, which is probably as much, if not more, subject to bad lightning storms than any place in the United States. These storms occur nearly every day during the season, which lasts from about May 10th to September 10th, but are more severe sometimes than at others. Often the same storm will pass over the lower part of the line and afterward over the part higher up, so that we generally get our full share of any manifestations in our vicinity. Unlike eastern storms, those of this section are accompanied by very frequent flashes, many of which are severe in their effects

Lightning arresters are located at the generating station and at both distributing stations in the Cripple Creek district at the end of the line. We also have four stations on the line, at approximately equal distances along the 25 miles. During the season of 1900, we had a great deal of trouble, owing to the fact that the arresters in use had no limiting resistance; in consequence, the machine current followed the arc established by the lightning, short-circuited the generators, and cut off the current from the line. This, of course, only occurred during exceptionally severe flashes. Early in the season of 1901, we installed arresters with carbon resistance pencil in series with the gaps, placing these in the three line stations that had given us the most trouble. We at first placed eight d.p., 2,000-volt arresters with all pencils and gaps in series, but, owing to the insufficient barrier surface between the resistance pencils, the discharge jumped across the terminals and produced short-circuit conditions. This was remedied by providing suitable barriers and more commodious ventilated boxes for the line stations. We also placed 16 of these arresters in multiple series at the point mid-way of the line where the effects were exceptionally severe, thus providing a double path to earth, with same resistance for each path as in the original connection.

In the matter of line stations, our belief is that they are a good thing, but that ordinarily not enough attention is given to providing commodious, suitable and well-ventilated boxes for these stations and sufficient barriers between resistance points.

On high-potential work with a large machine capacity, it is necessary to use a suitable limiting resistance, which should preferably be of simple design, and not liable to open circuit. As static wires above high-tension conductors are open to serious objection, it is our belief that frequent arresters, properly installed, will afford all needed protection on voltages up to 30,000, at least, and that work along lines suggested will also afford protection needed for the higher voltages. The success of our protection is attested by the fact that, notwithstanding the exceptionally severe local conditions and single transmission line, we have been able to operate during the lightning season, and for the last eleven and one-half months, without a single interruption to our service; a record that many low-tension, short-distance transmissions fail to obtain.

## P. G. GOSSLER

Between Richelieu Village, Quebec, and Montreal, Quebec, there are two transmission lines, consisting of three two-phase, four-wire circuits, each consisting of about fourteen and one-half miles of overhead bare copper wire and two and one-half miles of underground cables. The latter are in five different sections. Two of the overhead circuits are carried on one pole line and the third circuit on a separate pole line.

On the top cross-arms of each pole line, and 15 inches from the outside circuit wire on each side, is run a barbed wire on glass insulators; the third barbed wire is placed on an insulator on the top of the pole; the insulators being used to allow of a secure attachment of the barbed wire to the cross-arm. The three barbed wires are joined together on every pole, by a soldered joint, to a ground wire running down the face of the pole. This wire is held in position by staples, and passes at the bottom of the pole through a one-inch iron pipe ten feet long, and is then wound around the butt of the pole. The pipe is placed six feet in the ground, thus leaving four feet above the surface, to protect the ground wire from being broken at the place where it enters the earth. The size of wire used for ground wire is No. 6 B. & S. iron wire. The barbed wire used for protection on these lines consists of two No. 12 Birmingham gauge iron wire barbs three-eighths of an inch long, four-pointed, and spaced about every five and one-quarter inches. As the barbed wire is grounded at every pole and the poles are 90 feet apart, the wire is therefore grounded about 58 times per mile.

At the power house, Richelieu Village, are placed a bank of lightning arresters and choke coils on each transmission line. Twelve arresters and six choke coils go to a line.

The plant has been in operation for a period of three and one-half years, during which time we have never experienced a shut-down, either partial or complete, from lightning, although the distribution lines in the city and the distribution lines in the vicinity of the power house have had frequent serious interruptions due to lightning storms.

## F. A. C. PERRINE

It is assumed that the subject of protection of long-distance transmission lines is intended to cover only the question of protection of these lines against lightning and other static discharges, since any other interpretation of the word protection might involve every question concerned in the design and construction of such a transmission line. The protection of a long-distance transmission line is essentially the same as the protection of a shorter, lower-potential line; though by this I do not at all mean to convey the impression that the protection of high-potential, long-distance lines is no more difficult than the protection of other lines, since, as all know who have attempted the problem, there are many new difficulties arising in this problem and many difficulties of inconsiderable amount in lower-potential work, which rise to great proportions in all long-distance-transmission work. The reasons that there are greater difficulties in protecting transmission lines are:

*First*, on account of the extent and character of the territory traversed. In the summer time, lightning storms of small area are matters of frequent occurrence, and the problem is sufficiently difficult where one has to encounter only the storms that occur in any one section of territory, but where lines extend over distances from 20 to 50 or even up to 100 miles, it can readily be seen that the multiplication of the chances of interference from disturbances of atmospheric potential is very important, and that such a line must be protected efficiently at all times, irrespective of the particular character of the weather at the station. In consequence, those interesting means of lightning protection that are connected to the line only when danger is apprehended, can not in such cases be contemplated. Furthermore, transmission lines pass through country varying materially in elevation, and in certain conditions of the atmosphere there are produced along the line disturbances entirely apart from the existence of any lightning storms. Scientists have found by flying kites that at times a difference of a few hundred feet in elevation gives variations in air potential amounting to several thousand volts, and the probability of a line which extends over a broad stretch of country and surmounts noticeable elevations encountering such variations of air potential is very great, and must be guarded against. This one reason for the increased difficulty of the long-distance-transmission problem is, in itself, sufficiently convincing, but we must also remember that the laws of high-potential strain and high-potential arcs are not very thoroughly understood. All who have had experience extending over a number of years with alternating-current line protection, know that as the potential is raised step by step new principles seem to become important in the construction of the so-called lightning arrester. Calculations based on 2,000-volt protection are altogether unsatisfactory when the potential is increased to 5,000 or 10,000 volts, and doubling the voltage again brings in a new set of phenomena; while the final increase of potential up to 50,000 or 60,000 volts seems to throw to the winds all previously ascertained rules and regulations for procedure in lightning protection. The very means that might safely be used in protecting short low-potential lines, may cause damage in extremely long lines that would be worse than the difficulty they are desired to eliminate. All apparatus producing open-air arcs must be carefully avoided where the lines are long and the capacities and self-inductions great. Open-air arcs, being of rapidly oscillating character, actually raise the potential along such lines and introduce of themselves difficulties similar to those produced by lightning discharges. Before going into any question of the actual means used for protection of long-distance lines, we need first to recall to mind the fact that in protection of any line we are protecting,—*First*, against the induced surging currents on the line, produced by neighboring lightning discharges. Any lightning discharge in the neighborhood of a transmission line induces a high-potential current on the line which must be safely gotten rid of. *Secondly*, we must provide against the occasional striking of the line by a small side flash. *Finally*, we must do what we can to protect against a direct lightning flash; though generally this is necessarily destructive where it hits. General atmospheric differences of potential and small induced charges can be best taken care of by a frequently-grounded wire run in the neighborhood of the line. The familiar barbed wire, stapled to the tops of the poles and grounded at least as frequently as every fourth pole, illustrates this perfectly. Some trouble has been met from this means of protection, but there is really no reason for any serious difficulty to be expected from this source. In the first place, it is necessary to buy a barbed wire made of first-class material, and not apply to the nearest hardware store for the cheapest grade of fencing. For export and for this particular purpose, a particular high-grade of barbed wire is made, which, if carefully stapled to the poles and not kinked where the staples are driven in, should give no trouble from falling and interfering with the transmission line. Some reports have been received of a loss of energy presumed to be due to the presence of this grounded barbed wire, but careful measurements that have been made on lines loaded and unloaded, in order to find out the exact effect of this barbed wire as an absorber of energy, prove pretty conclusively that its presence does not produce any material loss of energy. It is true that it raises the capacity of the line by bringing the earth nearer to the line wires, but the difference in the capacity thus produced is not sufficient to cause condemnation of this means of protection, since wherever it has been used it is found at least to discharge the line when charged by differences of air potential, and also to relieve the other means of lightning protection when a storm was encountered. Choke coils, which are commonly used as a part of lightning-arrester outfit, undoubtedly sometimes have beneficial effect if there is a separate path to earth through a set of arresters for every choke coil; but there seems to be no doubt that their effect is present at certain rates of oscillation and not at others, consequently, they can not be considered as a sure means of aiding the lightning protection. The machinery itself generally has a very high self-induction which tends to induce the charges to go through a neighboring set of arresters rather than through the machinery, and cables leading into the stations are likely to be a much more efficient means of preventing a charge from entering the machinery than protection offered by a choke coil; but it is better to install choke coils, and to obtain the slight additional advantage they give, than to consider that without the use of choke coils there is necessity for only one path through the arresters to ground. It seems quite certain that any attempt to save lightning arresters by affording too few paths for the discharge to go to ground is the falsest sort of economy, and the only justification for leaving out the choke coil in any lightning-protection system would be the introduction of additional paths to ground scattered along the line and not all bunched at the terminals, where it is now the common practice to introduce all the lightning protection in long-distance lines. If a high-potential line is efficiently protected by the ordinary form of gap arrester, there is sometimes not sufficient potential present on the line to pass through the gaps of the arrester, and, at the same time, sufficient to pierce the insulation of the machinery. This high-potential charge can be gotten rid of through small-gap line dischargers, backed up by means for preventing the dynamo current from following the lightning discharge. One of the most efficient pieces of apparatus of this kind is in nature similar to the Branley coherer, which permits the passage of small currents of high periodicity and high voltage, but effectually prevents the passage of currents of low frequency and potential. It hardly seems necessary in any particular way to call attention to the various standard lightning-arrester types, since these are sufficiently familiar to all, but only to warn against the error of attempting to provide gap arresters with enough gaps for protecting high-potential circuits and preventing dynamo current from following, since when the potential rises above about 30,000 volts, this type of arrester is no longer available, and in series with a moderate number of gaps must be inserted either a resistance or a condenser; the probabilities being that the use of a condenser will be found to be the preferable plan. Finally, I would state that with the use of a barbed wire, lightning arresters, and line dischargers, we have done the best possible in the protection of any long-distance lines; but at the same time I feel constrained to confess that the engineers have still much to do before they can say that they have offered such perfect protection to long-distance lines that there will be no further trouble from this source.

## DISCUSSION

THE PRESIDENT: Are there any comments on these papers?

MR. CUSHMAN (San Antonio, Tex.): I had a very good illustration of the barbed-wire protection, in 1887. In a small plant in one of our Texas cities, they strung a barbed wire up over the lines, grounding at every fifth pole, for protecting the lines from lightning. The station arresters were the old-style saw-tooth and fuse arrangement. There was never a storm within three or four miles of the station or the city that did not have the apparatus on fire and fuses burned out. I removed all the barbed wire, and the trouble very materially decreased.

MR. LINCOLN: I ask Dr. Perrine whether protection due to a barbed wire, or to any wire for protection purposes, strung on the poles would not be increased by decreasing the resistance of the wire. Would not a low-resistance copper wire be better than a higher-resistance wire for that purpose?

THE PRESIDENT: That is the question which about one hundred members asked us to discuss; evidently they are all absent.

Mr. Lincoln: I should also like to ask Dr. Perrine if he thinks the barbs essential in the protection.

The President: I have been asked to request Mr. Scott to speak on this subject; is he in the room?

Mr. Scott: Anything in particular, or just in general?

Mr. Doherty: Anything in general from you in particular.

Mr. Scott: You have it in for me, but I will have it in for you a little later on.

I received a letter from my friend Mr. P. N. Nunn the other day, and he feels annoyed that his name should appear on the programme. He says that when he was asked to prepare a paper he replied, stating the present condition of his work, and assigning it as a reason for declining to comply with the request. You have placed his name on the programme and have printed his letter as a contribution on the subject. This was a good move, however, on your part. His report shows what is going on and the experiences they are having, and I think, on the whole, that what Mr. Nunn says is very good. They have been operating from 40,000 to 60,000 volts for several years with very little trouble and with little or no damage to the operating apparatus from lightning. Mr. Nunn's statement is fairly in line with what Mr. Lincoln has said about the experiences at Niagara Falls.

As to the lightning arrester, one of the functions of the arrester—its ability to protect circuits and other apparatus—has been fairly satisfactory; but going up to these very high voltages, as Dr. Perrine has pointed out, brings in new conditions, and it is impossible for the designers to meet them without getting the practical conditions of the operating circuits. That is a matter to which Mr. Wurts gave some attention a few years ago, and Mr. Thomas, who recently presented a paper before the American Institute of Electrical Engineers on the subject, expects to go out and visit some of these plants this summer and make investigations on the ground. It is a most excellent thing to bring up a subject of this kind before the practical men in the business, in order that they may keep in touch with the designers of lightning arresters and help them in making apparatus that will meet the practical conditions. The fact that these lines have been operating, and operating well, at these very high voltages, seems to me to speak well for what we may hope to have in the course of a few years, as the conditions are better known and the apparatus can be still further perfected. The arrangement of which Mr. Lincoln spoke, namely, a combination of series and shunt resistance, is one that was the result of a considerable amount of experimental work at Niagara Falls to determine the proper proportions for interrupting discharges across the arrester gap, and that which Mr. Lincoln has pointed out as being the most satisfactory arrangement on his circuits is the one that Mr. Nunn and Mr. Thomas are trying in conjunction on the high-voltage circuits of Mr. Nunn. Mr. Nunn may be considered as one of the pioneers of this high-voltage work, having operated a 40,000-volt line, I believe, a considerable time in advance of others, and his testimony on this subject is very excellent and valuable.

THE PRESIDENT: We have just three minutes in which to close this discussion.

Dr. Perrine: I suggest to Mr. Lincoln, if he finds that the barbed wire will not stand up under the strain of sleet storms, that he have it made of plough steel and it will stand as well as copper. The barbs are undoubtedly effective in protecting the line.

(The meeting then adjourned to visit the works of the Bullock Electric Manufacturing Company at Norwood.)

## SIXTH SESSION

President Doherty called the meeting to order, in executive session, at ten minutes before eight o'clock, Wednesday evening.

# EXECUTIVE SESSION

(Vice-President Ferguson in the chair.)

CHAIRMAN FERGUSON: I think we should now hear the report of the committee on dues, of which Mr. Nicholls is chairman.

### REPORT OF COMMITTEE ON DUES

MR. NICHOLLS: Mr. Edgar is chairman of the committee, but Mr. Edgar left for home this evening and he has asked me to make the report. The committee came to a unanimous decision on the measure that we propose to recommend. I think you will all remember the suggestion made by President Doherty in reference to a new scale of membership dues. After discussing it, we can see that there is a great deal of merit in Mr. Doherty's suggestion. We have considered that it was perhaps further than we dared go all at once as regards the dues of the association, and it is decided to recommend to the association that, in order to encourage the entrance of new members from the smaller communities, we should make a reduction in the annual dues for central stations in all cities below 20,000 population. Of course it is understood that the dues are only a small portion of the expense of being an active member of this association. Take, for instance, a member who may come to Cincinnati from a small town in Connecticut, or New Hampshire, or New Jersey, and it means that in addition to his present dues of $25 he probably has to spend from $75 to $100, or more, to enable him to attend the sessions of this convention. This is a serious tax if the manager of one of these small companies has to pay it; and if the company is called upon to pay it, the directors are apt to think it a large amount to assess a company for a holiday trip for one of its officers to represent the company at the convention. On the other hand, I think we all realize that some of the most active men we have in the association are the managers or representatives of the smaller interests. In other words, they have to overcome every sort and condition of problem, which problems in the large stations are divided among the various executive officers and engineers and electricians. They have to come in contact with all kinds of problems of one kind and another, and they are of great assistance in the deliberations of this body. It is therefore decided to recommend that there be an initiation fee of $25 charged for all new active members, beginning with the first of next year—January 1, 1903; that, beginning with the first of next January, the dues for central stations in towns of less than 20,000 population be reduced to $10, but any new members from the smaller communities wishing to join the association between now and the first of January should be allowed to do so on payment of $10, without the entrance fee, which only becomes operative the first of next year. It is also decided to recommend that for all central stations in towns of from 20,000 to 300,000 population, the dues remain as at present, $25, and that for all central stations situated in towns having a population above 300,000, the dues be $50 per year. We thought that was about as even and equitable an arrangement as we could recommend at the present time. While we do not claim that it is a perfect substitute for Mr. Doherty's suggestion, or that it will be found in practice the best that can be devised, it is probably as wide a step as we could take at this time, considering the different interests in the association, without causing more or less discussion and disorganization. In brief, then, the recommendation of the committee is that after January 1, 1903, an entrance fee of $25 be charged to all new active members alike; that the annual dues of active members representing central stations in cities and towns under 20,000 in population be $10; that the dues of central stations in cities and towns between 20,000 and 300,000 in population be $25, the same as at present, and that the annual dues of central stations in cities of over 300,000 inhabitants be increased to $50; it being understood that any new members from the smaller communities shall be at liberty to enter the association until the new year at the fee of $10 per annum.

MR. AYER: Is the entrance fee to take effect before the first of the year?

MR. NICHOLLS: I should have said further that any central station from any city joining the association between now and the first of the year may do so without the payment of the entrance fee.

MR. DOHERTY: I want to say that this is not the unanimous report of the committee appointed to consider the subject. I do not agree in it, and I do not object to it. I think it is a step in the right direction, but I want to put myself on record as not being fully in accord with these recommendations. I was compelled to leave the conference before the work of the committee was finished, but I think it is a step in the right direction.

MR. WILLIAMS: I move that the report be adopted.

(The motion was carried.)

CHAIRMAN FERGUSON: I will name the committee that I have appointed on Relations Between Manufacturers and Central-Station Companies: Charles L. Edgar, Boston, chairman; Henry L. Doherty, Denver, and A. C. Dunham, Hartford.

With the permission of the convention, I will add the name of Henry M. Moses to the committee on memorials.

We have a communication from Mr. W. Worth Bean, of St. Joseph, Michigan, saying that he regrets that business engagements prevent him from being present at the meeting, and he wishes us success.

(President Doherty in the chair.)

THE PRESIDENT: I will now call for the report of the committee on nominations.

## REPORT OF THE COMMITTEE ON NOMINATIONS

MR. NICHOLLS: Mr. President and gentlemen: I have been for several years a member of the committee on nominations, but I am inclined to think that this is the last occasion on which I will allow my name to be put before the association in that connection. I do not think I have been out of this hotel, except for a short distance, since I arrived here, and I can assure you that your committee has worked hard in trying to get at the true feeling of the active members as to what their desire was regarding the officers for the coming year. My associates, Mr. Ayer and Mr. Fairbanks, have been indefatigable. I think we got to bed at three o'clock this morning and were up again at daylight, almost, and I hope the conclusions we have arrived at will meet with a favorable reception at your hands. Your committee begs to place in nomination for president, Mr. Louis A. Ferguson, of Chicago.

Before passing on to the next nomination, I want to say personally, on behalf of the association, that I think it would be impossible to make a better selection. I have been connected with this association for a good many years and have known of Mr. Ferguson's work. Mr. Ferguson has not obtruded himself upon the association at any time, but he has always been on hand and always willing to prepare exhaustive papers dealing with subjects of great interest to members; and when he has been called upon by the executive committee to spend time and money on behalf of the association, he has always been to the front. I think this is a well-merited honor for Mr. Ferguson; I think the association is honored by Mr. Ferguson's acceptance of the office of president.

Your committee places in nomination for first vice-president, Mr. Charles L. Edgar, of Boston. Mr. Edgar is also well known to you all. He has been identified with the electric-light interests from the earliest inception of the business. I do not know of anyone who has been interested in central-station management antedating Mr. Edgar.

For second vice-president, we nominate Mr. Ernest H. Williams, of Williamsport, Pennsylvania. It so happens this year that there are six gentlemen to be placed in nomination for positions on the executive committee. There are three members who retire by expiration of their term of office. Mr. Edgar and Mr. Davis make vacancies by accepting higher office in the councils of the association, and I think there will be a suitable resolution submitted to you at a later stage, dealing with the death of General Howell, one of the members of our executive committee.

For members of the executive committee to serve for three years, we nominate the following: A.

C. Dunham, Hartford; P. G. Gossler, Montreal, and H. T. Hartman, Philadelphia.

For members of the executive committee to serve for two years: J. C. Perkins, Youngstown, Ohio, and C. F. Hewitt, Elkhart, Indiana.

For member of the executive committee to serve for one year, Arthur Williams, New York.

I may further state that the committee has two other matters to speak about. Mr. Hunt, who was second vice-president of the association, approached the committee voluntarily and stated that he wished to withdraw his name from nomination, as he felt there were so many large questions coming before the association at the present time that were so closely connected with purely local interests in the United States, that as a Canadian he thought it his duty to withdraw from any higher office in the association; at all events, for the present time. I think we can all appreciate Mr. Hunt's action in this matter, as it is continuing his best efforts for the best interests of the association.

In view of the many services that Mr. Hunt has performed for the association, your committee would recommend that a vote of thanks for past services be tendered to Mr. Charles B. Hunt, of London, Ontario, and that the resolution of thanks be duly engrossed and forwarded to him.

(The motion was carried.)

Mr. Nicholls: As you all know, Mr. James B. Cahoon was appointed secretary and treasurer by President Doherty, and his appointment was indorsed by the association.

Another recommendation that the committee makes is that Miss Harriet Billings be officially recognized as the assistant secretary and treasurer of the association. Miss Billings has been acting as assistant secretary for a number of years. During the past year or two her duties have been heavy. Those of us who have been brought more in contact with the executive office of the association know the work she has done for us all. She has been untiring, and not only has she been untiring, but she possesses intellect and acumen to a remarkable degree for a woman engaged in a semi-technical business such as that of assistant secretary of the National Electric Light Association, and your committee recommends that Miss Billings be formally recognized as assistant secretary and treasurer of this association.

THE PRESIDENT: What do you wish done with the report of the committee?

MR. BOTTOMLEY: I move that the report of the committee be accepted.

(The motion was carried.)

THE PRESIDENT: You now have certain nominations before you. It is customary for someone to move that the secretary be authorized to cast the ballot electing these gentlemen, if you are in favor of the recommendation of your committee.

MR. FIELD (Columbus, O.): I move that the secretary be instructed to cast the ballot of the association for the officers named.

(The motion was carried.)

THE PRESIDENT: I declare the gentlemen elected.

(Questions Nos. 27 and 28 were then taken up, and the answers read, for which see Question Box.)

MR. NICHOLLS: Do I understand that this is the last executive session of the convention? I do not think it is likely that we shall call another, and for that reason someone should move, unless there is a permanent committee, that a committee of five on resolutions of thanks be appointed to express our thanks to those who have been courteous to us and have entertained and worked for us.

The President: I had it in mind to appoint such a committee, and if there is no objection I will do so.

(The executive session then adjourned.)

# OPEN SESSION

THE PRESIDENT: Will Mr. A. W. Field and Mr. A. J. DeCamp please escort Mr. Ferguson, the newly-elected president, to the chair?

MR. FERGUSON: Mr. President and gentlemen: I thank you most heartily for the honor you have conferred upon me in electing me to the presidency of your association, and I am especially gratified at the unanimous manner in which you have elected me. I shall endeavor, with your assistance, to administer the duties of the office to your entire satisfaction.

THE PRESIDENT: I congratulate you, Mr. Ferguson. Gentlemen, I think we shall all find that the affairs of the association will prosper under Mr. Ferguson's management, if he keeps his usual good health.

(President-elect Ferguson in the chair.)

MR. NICHOLLS: There is a resolution, Mr. President-elect and gentlemen, that I wish to submit to-night, because I think a great many of the members will be leaving to-morrow morning, and I want this resolution to be unanimous and as hearty and responsive as can be. I want to propose a vote of thanks to our retiring president, Mr. Doherty. I do not think any of you can appreciate the amount of work that Mr. Doherty has done this year on behalf of the association. The mere fact of getting up the programme placed before you, extensive as it is, has entailed an enormous amount of work, and Mr. Doherty has been indefatigable in season and out of season in working for the interests of this association. In some things I agree with him, and in other things

I do not agree with him, but at the same time I recognize his zeal, his ability, and his disinterestedness, and I therefore have much pleasure in moving that a formal vote of thanks be tendered Mr. Doherty, the retiring president, for his efforts on behalf of the association, and that a set of engrossed resolutions, indicating the esteem of the association for its retiring president, be prepared in due course and presented to Mr. Doherty.

MR. AYER: I have much pleasure in seconding the motion.

PRESIDENT-ELECT FERGUSON: Before putting the motion, I want to add a word to what Mr. Nicholls has said. Mr. Doherty, in his opening address, was very brief in speaking of what the officers of this association had done during the past year. Mr. Doherty might well have said what the president of the association had done during the past year, because I have been vice-president of the association and I know that the officers of the association who have done the work are represented by one man, and that is our retiring president, Mr. Doherty. A man of work, he has been; you can see the results before you, in all the papers that have been presented, and in the general conduct of the affairs of the meeting. The labor involved in the Question Box alone has been simply tremendous. Mr. Doherty has handled all these matters single-handed in connection with the assistant secretary of the association, Miss Billings, and has been practically unaided by the executive committee or other officers of the association. Therefore, it is with great pleasure that I put this motion before you. All those in favor of extending a vote of thanks, as Mr. Nicholls has expressed it, please signify the same by rising.

(The motion was unanimously carried.)

MR. DOHERTY: Mr. Chairman and gentlemen: If I have worked hard for the success of this meeting, I certainly have been well repaid for it by the thanks you have given me and the appreciation you have shown for my labors. I have tried to make this meeting a success. I can not agree with Mr. Ferguson that I have done it all alone. I did not ask Mr. Ferguson to take up any of the hard work of the association—although he was ready to do it—for he was very busy and we thought we could carry it along by ourselves. I do want to say, as I said in my presidential address, that Miss Billings, I think, deserves more credit for this meeting than does any other one person. I want to share in the credit if the meeting is a success, but Miss Billings deserves more credit than anyone else.

PRESIDENT-ELECT FERGUSON: I have the pleasure of introducing Mr. Russell Spaulding, who will read a paper on "Display Lighting, Signs and Decorations."

Mr. Spaulding read the following paper:

## DISPLAY LIGHTING, SIGNS AND DECORATIONS

The fact that a large number of small units of light is infinitely better for decorative purposes than large and intense light centres, has long been known. Before the advent of electricity in a commercial form our chief illuminant was gas, and this in turn was preceded by the candle.

The candle afforded but a small unit of light, and until such improvements in gas lighting as the Welsbach burner and others had been invented, gas jets were subject to the same restriction. These limitations may have been the reason for forcing upon decorators the use of a large number of small units of light, or it may be that their artistic instincts convinced them that nothing else would do. It is noteworthy that those inventions in gas lighting which permit intense light centres have never been utilized except for the purpose of dispelling darkness, and have never made part of a scheme of decorative lighting.

The arc lamp was the first manifestation of electric lighting in a commercial form, but its very intensity formed an insuperable obstacle to its adoption for decorative purposes.

The next development was the incandescent bulb, at first large and of great candle power, then gradually diminishing in size and intensity until the sixteen-candle-power lamp became, and is still admitted to be, the standard for general illumination.

For decorative purposes the first notable use of ten and eight-candle-power lamps on a large scale was at the World's Fair in Chicago, and the eight-candle-power lamp proved its desirability by the further success attained in the lighting of the Pan-American Exposition. To-day, the four-candle-power lamp is the standard for most decorative work; one, two and three-candle-power lamps being also largely used.

What seems to be the least understood is the proper relation between the size and intensity of light units as compared with the magnitude of the display under consideration. This involves the "point of view." When seen at a great distance, and from the water line, the arc lamps on the Brooklyn Bridge form a beautiful diadem, but from the bridge itself the effect is entirely lost, as the proximity of the beholder is out of proportion with the distance from arc to arc and with the distance from arc to beholder, and, further, with the intensity of the arcs themselves. No more beautiful sight could be imagined, however, than this same bridge outlined with eight-candle-power frosted incandescent lamps one foot apart; the vista from the bridge itself would be marvelous and at a distance the effect would be that of continuous lines of fire.

A few general rules might be formulated as follows: The nearer the distance to the observer, the smaller the unit should be in size and intensity and the nearer the units should be to one another. Displays at short range, such as indoor decorations, should invariably consist of frosted lamps, and the distance between lamps should be such that the halation has practically a uniform value from bulb to bulb, especially where continuity of line or curve is essential. Obtrusiveness and glare should be studiously avoided, and existing conditions of the surroundings should always be taken into account.

In electrical displays as in everything else success depends on harmony. The creation of a harmonious whole is a problem even where only white lights are used; where color is introduced it becomes more complex. A mistake that is often made is to introduce too many different colors in decorations. Single-tone effects, or effects involving white lamps alternating with some one color, are the most satisfactory. White frosted and green frosted bulbs in alternation will fit most cases; especially where natural greens are used. A decoration consisting of natural greens and gold frosted lamps is most effective in a hall the walls of which are neutral in tint.

In the outlining of buildings plain lamps may be used, although frosted lamps will give a better effect. Twelve inches is a good distance to maintain between lamps. Where the building itself has architectural excellence, the main lines may be accentuated by electric outlining with good results, as they were at the Pan-American Exposition. Where the building possesses no particular beauty, garlands and festoons may be employed to supply the attractiveness that would otherwise be wanting.

The aim and object of all display lighting, either in decorations or signs, is to make an attractive effect. This is best attained, as said above, by avoiding glare and obtrusiveness. The onlookers should not receive the impression that some one is making an electrical display; the impression should be that life and light have been infused and evenly disseminated in a decoration that otherwise would have appeared dead, by comparison, in reflected light only. That these facts are daily forcing themselves more and more upon a thinking public is evidenced by the increasing demand for means toward the ends enumerated; that these demands are genuine is evidenced by the amount of money and energy that have been expended to meet them.

The chief obstacles to decorative lighting have been: Great cost; defacement of rooms by installation of temporary decorations; lack of safety in apparatus; lack of small lamps that can be used in multiple on 100-volt to 120-volt circuits; length of time necessary to prepare for decorations; length of time consumed in erecting same. The last two conditions have in the past made it impossible to undertake elaborate decorations at short notice. All these obstacles and many others have been successfully overcome, and to-day the market affords apparatus that permits elaborate decorations to be made at a reasonable figure, without defacing property, with perfect safety, with lamps less than one inch in diameter, of one-candle-power, operating in multiple on 120-volt circuits, without preparation, at short notice, and in a few hours. The most notable example of this was the decoration at the Metropolitan Opera House, in New York, for the gala performance in honor of Prince Henry of Prussia. Here, without previous preparation, 8,500 incandescent bulbs of four candle power were installed in the most inaccessible places in the space of fourteen hours, without driving a single nail or screw, without breaking a single lamp or blowing a single fuse; the installation including a movable drop curtain, sixty feet by sixty feet, containing 3,000 lights.

The shortcomings of signs have been: Their expense; their fraility when exposed to the deteriorating effects of the weather; their clumsiness and unattractiveness, and their limitations to some one combination of letters or to some one design. All these have been met and overcome. We have to-day all kinds of signs: changeable signs operated by keyboards that permit the instantaneous spelling of any desired word or sentence; detached metal letters of all shapes and designs, which permit the consumer readily to make up any legend; decorative signs of all shapes; sockets joined with adjustable links, permitting the rapid formation of any letter or design; electric-lighting boards on which any combination of letters or design may be traced and then outlined electrically by implanting bulbs.

Here, again, the relation between the size and intensity of the bulbs themselves as compared with the size of the letter is not always given proper consideration. Another necessity for proper effect, which seems to have been understood by but few people, is the necessity of a light-absorbing background in order to make the sign more readable by night and attractive by day. A walk in the evening on Broadway, New York City, or on any similar thoroughfare of our large cities, reveals the fact that the great majority of signs in use leave much to be desired, and that in the daytime most of them are positively unsightly.

Frosted bulbs should invariably be used except where the sign is at a great height.

In the foregoing, the exclusive use of small lamps, from the point of view of the artist and decorator, has been advocated. Let us now consider the matter from the point of view of the central station manager. The central station manager's chief aim is, of course, to have as much current consumed as possible, and to this end he will naturally encourage the use of all devices that consume current and oppose all devices calculated to reduce current consumption. Small lamps are in this last category, and therefore meet with opposition or fail to find encouragement. Such a policy may be advisable in general illumination, but in sign or decorative lighting such reasoning would be fatal. In display lighting the chief object is to produce a fine effect. This object the larger lamp defeats and the small lamp accomplishes. Small lamps will, therefore, secure for the central station a consumption of current that otherwise could not exist.

Leaving attractiveness out of consideration, a consumer might be deterred from erecting an electrical sign comprising one hundred sixteen-candle-power lamps, owing to the large cost of maintenance. The cost of maintaining one hundred eight-candle-power lamps might also deter him; whereas the maintenance of one hundred four-candle-power lamps might seem reasonable enough. Furthermore, the consumer, if pleased with his sign, will probably want several others. Then, again, he will be liable to burn the signs for more hours per day than he would if the bulbs were larger, and in the end will consume much more current than he would consume were he restricted to large lamps. The force of example and keenness of competition will come to the aid of the central station, and merchants will vie with each other in making electrical displays.

Where the incandescent bulb is used simply to dispel darkness and to permit the pursuit of business when daylight fails, the consumer will try to get the most light for the least money and will exercise an economy that the central station considers deplorable. Give your consumer, however, a method of lighting that is not only going to dispel darkness in his premises, but is going to please his eye and enhance the beauty of his store or residence, or, perhaps, supply beauty where none exists,—in short, give him a method that is attractive—and you will find that he will use more current than he ever did before. The merchant will not only use it in his electroliers, but he will use it for making his window displays attractive. He will use it for illuminating advertising cards; he will use it for electric signs if they are going to cause comment and draw trade to his place of business. On occasions that he wishes to make festive, he will replace the bunting and floral decorations with electrical festoons and garlands and emblems, or, perhaps, add them to the other decorations, whereas he would not consider doubling up the number of his electroliers, nor would he consider converting his place of business into an artificial sun parlor.

In residences, the consumer will be tempted on festive occasions to add to the glory of the occasion by introducing more or less elaborate decorations; on the table for a banquet, about the rooms for a ball or reception, and in the summer time outside of his house, his verandas, his trees, his lawns, may all be made to look like fairyland; the chief requisite being rapidity of execution, reasonable cost, and, above all, a small lamp. In very few instances will the consumer consider the amount of extra current that he will consume for a temporary decoration; he will be mainly concerned with the cost of the decoration itself. To-day the markets afford means of making these decorations at a reasonable cost, and it is to the central-station manager's best interests to encourage their use.

The subject of illumination and display lighting has been most deeply and ably dealt with by Mr. Luther Stieringer and others. Among the many instructive and interesting papers that Mr. Stieringer has prepared and published, I have selected for reprint a paper that he read before the Association of the Edison Illuminating Companies, at a meeting held in Buffalo, on September 10, 1901; also, through the courtesy of Mr. T. C. Martin, an article entitled, "From Christmas Tree to Pan-American," published in the *Electrical World and Engineer*, August 24, 1901. These reprints have been affixed to and made part of this paper.

Those who are further interested will be repaid by a perusal of the following: Dr. Louis Bell's articles on electrical illumination appearing serially in the *Electrical World and Engineer*; "Ground Lighting at the Pan-American and Prior Exhibitions," by Luther Stieringer, *Electrical World and Engineer*, July 20, 1901; "A Brief History of Luminous Fountain Developments," by the same author, *Electrical World and Engineer*, September 14, 1901; "Decorative Lighting at the Pan-American Exposition," appearing in the *Electrical Review*, June 22, 1901. In the *Western Electrician* of August 17, 1901, "Edison at the Pan-American Exposition;" in the same paper, May 18, 1902, an interesting article by Orrin E. Dunlap.

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PRESIDENT-ELECT FERGUSON: I am sure we feel grateful to Mr. Spaulding for this interesting paper. There is attached to this paper one by Mr. Stieringer, which is a description of the lighting that has been done at the various expositions throughout the country. As the hour is growing late, perhaps we can omit the reading of that paper here, because you can take it home and read it at your leisure.

We will now have a paper on "Possibilities of Sign and Decorative Lighting," by Mr. E. J. McAllister.

Mr. McAllister read his paper, as follows:

## POSSIBILITIES OF SIGN AND DECORATIVE LIGHTING

"Like the stockman's brand, it literally burns its message into the public mind," is the heading used in advertising the product of a certain manufacturer of electrically illuminated signs. The comparison is an apt one, for scarcely anything leaves so indelible an impression upon the human mind as does that object, the principal part of which is light judiciously arranged.

That merchants begin to realize the overwhelming value and importance of a well-lighted place of business, is demonstrated by the attention that is now given this detail in constructing modern mercantile buildings, and as the interior attractiveness of a place of business is very likely to be judged by external appearances, the merchant seeks to make his place of business as attractive and cheerful as possible externally as well as internally.

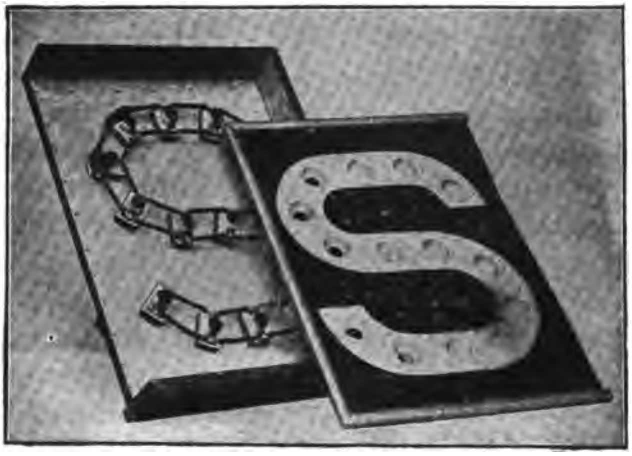
By the introduction of the incandescent lamp the many difficulties of effective store lighting by artificial means were reduced to a minimum, but nowhere has the difference in effect been so marked as in the external appearance of such buildings as are devoted to purposes calculated to draw people to them after dark.

In the city of New York, where a total of a little over one million sixteen-candle-power lamps, or their equivalent, are in circuit, it is estimated that a little more than ten per cent of the total incandescent current supplied is used for out-of-door sign lighting. Considering that this sign lighting is confined to strictly mercantile thoroughfares like Broadway, while the circuits of the local illuminating company cover an enormous territory, this proportion of sign lighting is considerable, and especially so when it is remembered that practically all of these signs use nothing higher than eight-candle-power lamp units.

Out-of-door lighting has for the most part been spectacular in character, rather than decorative, as its purpose was to attract attention in the most persistent manner possible; but with the increased and cheapened facilities for handling this class of lighting, and as a result of a more thorough knowledge of the artistic possibilities for units of light properly handled, the tendency has steadily been in the direction of a more decorative effect. Even the ordinary electrically illuminated sign is now relieved of that crude, unfinished appearance that not long since was considered an unavoidable characteristic of such production, and as now constructed can be made to avoid entirely the hideousness that formerly made it an objectionable blot upon the architectural features of a building.

ILLUMINATED EMBLEM

For purposes of spectacular or decorative public illuminations, the incandescent lamp has naturally superseded all other illuminants. Not only has lighting of this class in its most advanced form been a particularly important feature of modern exhibitions, such as the Pan-American, but even a city providing entertainment for a multitude of visitors upon some special occasion no longer considers its programme



DETAIL OF FLUSH LETTER CONSTRUCTION.

A MODERN THEATRE ENTRANCE

complete unless including a public electrical illumination of some pretension. Even pyrotechnical displays are being abandoned in favor of spectacular electrical illuminations, the stated reasons being that, at best, the fireworks entertain for but a few moments, and even their success or failure is largely dependent upon weather conditions. The electrical illumination is a success in any kind of weather; its varied effects are calculated to entertain and charm the eye, not for a few moments merely, but for hours or for as long as is desired each night. Moreover, a journey to some distant, overcrowded inclosure far enough from the city to minimize fire risks is not necessary.

The incandescent lamp lends itself so readily to all forms of architectural and emblematic embellishment, and is so adaptable to the carrying out of attractive color schemes in great variety, that the city's public buildings, the principal thoroughfares, or perchance a centrally located park, are the settings best adapted to the needs of an effective electrical illumination. Most important of all, moreover, is the fact that the electrical illumination is not extravagantly expensive considering its great value as a source of really enjoyable entertainment.

The external lighting of commercial buildings will undoubtedly be more or less closely confined to the use of illuminated signs of one description or another, as what is desired here is a permanent individuality of effect that readily distinguishes one place of business from any other similarly well-lighted building in the immediate vicinity, and in no way can the characteristic of marked individuality be so completely attained as by means of the electric sign. The field of decorative lighting—or, perhaps, more properly speaking, spectacular lighting of a decorative character

—is, however, a sufficiently large one even if confined strictly to interior embellishments or temporary out-of-door illuminations.

During the past two years considerable attention has been given to the subject of interior decorative illuminations, especially by large retail stores or department stores, and a great variety of really beautiful effects have been obtained. In this class of work, however, as in any purely decorative work, an experienced touch is essential to the best results, and if possible the general scheme should be laid out by some competent person thoroughly versed in the matter of artificial light and its value under varying conditions. Too much or too little light, too many or too few units, or units of improper intensity or erratic spacing,—will always seriously injure effects that might otherwise be perfect. Great care must also be exercised where an attempt is made to use colored lamps. Nothing is so annoying to the esthetic eye as the indiscriminate use of red, white and blue lamps, with which the average electrician insists upon sprinkling his decorative work. Patriotic it may be; artistic, never! While even the spectacular effect aimed at is killed as a result of lamps of the various colors not being equally distinct, to say nothing of the destroyed artistic harmony.

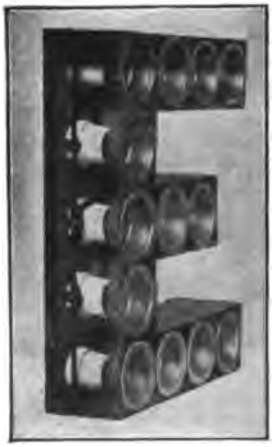
The subject of show-window lighting deserves more than passing notice. To display properly the goods exposed in a window, a top light thrown strongly upon the articles exhibited, but screened from the eye of the observer in the street, is absolutely essential; but in the way of attracting attention to some particular line of goods displayed, nothing can be more satisfactory than a touch of spectacular or decorative lighting. This work should be of such a character as not to show obtrusively by daylight, and, in order to avoid glare at night, the lamps used should be of very low candle power. It is often found that a mechanical movement, or something in the way of optical illusion, which lends life and spirit to the display, is very desirable. Most of the large department stores that constantly use such window displays have employees specially skilled and experienced in

FOR WINDOW DISPLAY. SAILS REVOLVE SLOWLY, CHANGING COLORS this class of work, who provide such novelties from time to time; and there are also one or two manufacturers of electrical specialties from whom may be rented at reasonable rates any one or more of a large variety of such display pieces, society and patriotic emblems, etc., suitable for use either in show windows or wherever desired; those of the pieces designed especially for indoor use at close range usually being very handsomely finished, as well as unique and attractive in design.

For purposes of decorative lighting in show windows, and, in fact, for purposes of purely decorative interior lighting generally, nothing is so well adapted, or lends itself so gracefully to the usual requirements of the case, as the miniature series-burning lamp, with its low candle power, small and unobtrusive receptacle, and low-current consumption. This advantage of the miniature lamp also applies in the case of very small illuminated letters — letters less than ten inches in height—where a large bulb would appear entirely out of proportion.

The greatest barriers to the more common use of decorative lighting and illuminated sign advertising have heretofore been—first, the seemingly high initial cost of the installation, and second, the cost of maintenance in the form of bills for current consumed. In reply to such arguments it might be stated that any *good* form of advertising is expensive; and the experience of thousands of users of electric signs who have kept their lights burning for upward of ten years, and who would not think of discontinuing their use now, would seem to indicate the quality of electric-sign advertising as "good." What applies to an illuminated sign also applies in a great measure to decorative lighting in general, as it can not be denied that the happiest possible medium through which to approach the public is the sense of sight, and the universal appreciation of light artistically or spectacularly displayed.

As a matter of course, it is not to be expected that every shop in a given block would find such advertising sufficiently profitable to be within reach, even if the cost of it were fifty per cent, or perhaps even seventy-five per cent, below present rates; neither would they find the same amount invested in local printer's ink any more profitable. It is to the live business man, who has a class of merchandise that warrants his going to some trouble and expense to tell the local public of that fact, that the features of advertising by means of light appeal; for in no other form of advertising is the matter of expense so absolutely under instant control. A sudden storm, or other unfavorable condition, renders its use unwarranted; the throwing of a switch instantly stops



Detail of Box Letter Construction

all expense except the slight charge of interest on investment. As a matter of fact, however, the expense of illuminated sign work is slowly but constantly decreasing, and such work is being produced to-day for from forty to fifty per cent less than was charged only a few years since for a product much inferior both in general appearance and actual merit. Consequently the initial cost of a properly constructed illuminated sign is now so slightly greater than that of a first-class product of any regular sign-writer's skill as practically to remove the first barrier, initial cost. The second difficulty—cost of maintenance—is a problem that can be solved only by the local illuminating companies, though a step in the right direction has undoubtedly been made in the commercial introduction of low-candle-power, multiple-burning lamps. It is a well-recognized fact that for ordinary sign lighting, unless in large signs designed to be read at a great distance, a fifteen to twenty-watt lamp is really more desirable than one of greater brilliancy, as it produces sufficient light to illuminate its surroundings adequately, yet does not produce that glare which frequently renders the average small-lettered electrical sign absolutely unintelligible when viewed from a little distance; and in an electric sign using several hundred units, it makes quite a difference whether each unit is consuming twenty-eight to thirty watts or only fifteen to twenty watts, especially if the low-watt lamp is as satisfactory for its illuminating purposes as one of higher candle power.

From the standpoint of the central station the low-candle-power lamp might be regarded with extreme disfavor as a revenue producer, especially by those illuminating companies furnishing free renewals; but considering the probable increase in load that would result from more common use of electric signs and longer hours of burning, it is certainly debatable whether the low-candle-power lamp, with its low economy and correspondingly long life, is not a profitable investment after all.

Incidental to this discussion of the cost of maintaining an electric sign, it might not be amiss to say a word or two regarding another item coming under the heading of cost of maintenance; namely, cost of repairs. A poorly-constructed sign, or one imperfectly protected against the penetration of rain or snow to its interior, will not infrequently necessitate an annual repair bill equal to fully half the original cost of the sign. As a result of all this, not only does this customer soon discontinue the use of his sign, but his neighbors, discouraged by his experience, learn to regard with disfavor any proposition likely to subject them to similar experiences. Signs properly constructed and protected against the action of the elements have been in constant service for from eight to ten years, their only expense for repairs being an occasional coat of paint, and these signs are to-day in practically as good condition as when originally installed. The difference in cost of protected and unprotected signs is only about ten per cent, and in any event is too slight to be considered in view of the difference in value.

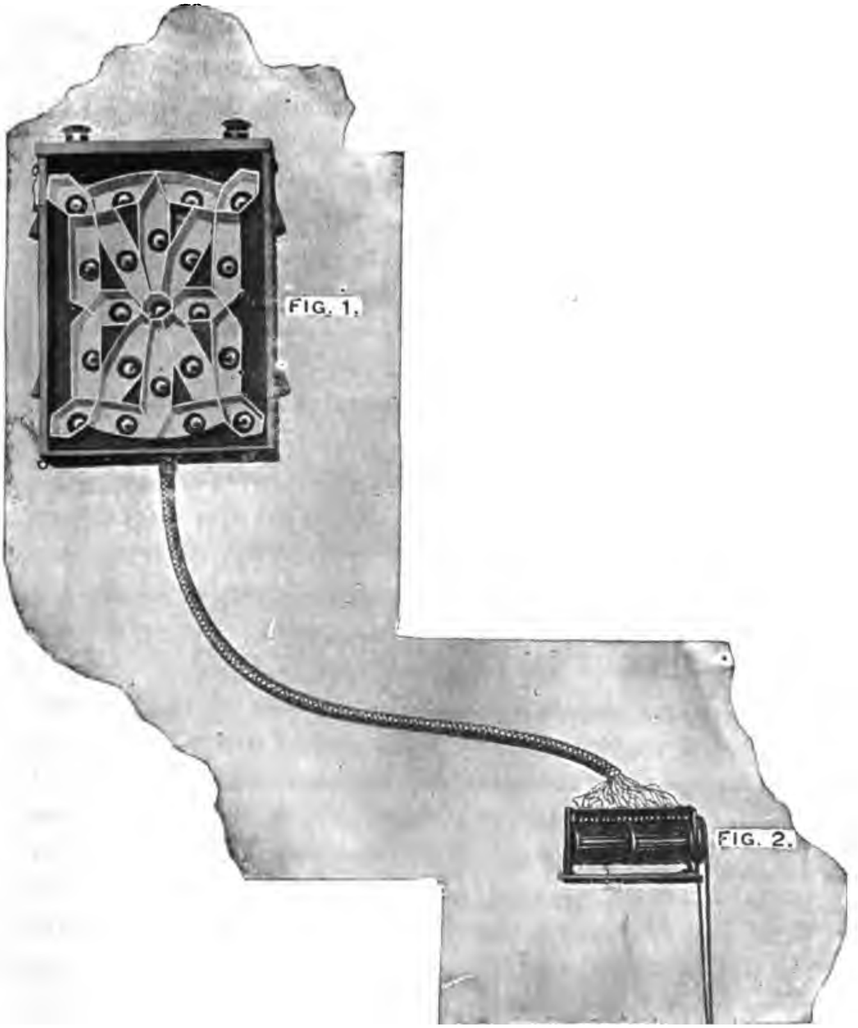
To a great extent, illuminated signs are still considered among the luxuries of advertising, but the demand for them begins to come from that numerous class of smaller tradesmen who heretofore annually used more or less space in local newspapers but now find it profitable to use a portion of their advertising appropriation in a more modern manner. The proportion of expenditures in the various forms of advertising opened up as a result of the ready adaptability of electricity, is constantly increasing, and how to encourage this tendency further on the part of their customers is becoming an important question to managers of central stations. Many solutions of the problem have been tried and the results have generally been satisfactory; especially so where the action taken was based upon the theory that sign and decorative lighting was essentially a special, and as yet practically undeveloped, branch of central-station business, a class of custom that could be secured in any quantity only as a result of liberality of a comprehensive kind upon the part of the central station.

Among the more common of the methods employed by illuminating companies to secure an increase in sign and decorative lighting on their service, has been the establishment of special rates on all such business, or the maintaining of a generous scale of discounts based on a customer's monthly consumption of current. One lighting company operating in a large eastern city adopted a policy of furnishing and maintaining any ordinary electric sign or decorative illumination designed by any customer who agreed to use it a given number of hours per annum, the consumer paying for current at regular meter rates. Other central stations have for some time followed the practice of making a very liberal special rate on current used in this manner, in addition to which they furnish and install any sign or other special lighting material required, charging the customer in some instances really much less than the article actually cost them, or, if desired, permitting the customer to pay them for it in instalments that would scarcely be felt. Fixed rules of liberality in such matters are extremely difficult to follow with any degree of satisfaction, however, as so much depends upon the character of the customer that is being dealt with, and the nature of his business; the first because of its relation to the moral risk; the second because of its largely governing the commercial risk as represented by the total amount of current likely to be used.

Upon the part of the manufacturers of material particularly adapted to the requirements of the various forms of special lighting under discussion, considerable progress has been made during recent years, both in point of increased adaptability, and of reduction of expense, nor is it to be supposed that the end is yet reached.

Among the more recent novelties that have been offered in the way of improvements in material for use in decorative or sign lighting might be mentioned the "Mason Monogram" or "Changing Letter" system of signs; the "Elblight" or "Pin Lamp," and the "Brewster" or "Linked Receptacle" systems: these last two being equally suitable for decorative or sign work.

The "Monogram" or "Changing Letter" system above referred to, consists of a glass-faced box, inside of which is arranged a group of oddly-shaped cells, containing an incandescent lamp. When all the lamps are lighted the figure seen upon the glass front of the box is merely a luminous geometrical figure, but if the lamps are lighted in proper combinations, any desired letter or numeral is produced with tolerable accuracy of detail. A simple mechanical attachment is provided with each box or monogram, by means of which a long series may be automatically produced in any desired sequence, so that one monogram may be used to spell out words, letter by letter; or if several monograms be placed in rows, entire words, or even complete sentences, may be



**Detail of Mason Monogram System**

flashed in and out in ever-changing variety. The current consumed by this type of sign is very low, as relatively few lamps are required to produce any given letter. The cost of the monograms and mechanism is, however, rather high, and the fact that it operates upon the principle of a transparency renders it valueless as a day sign—a serious objection in the minds of most users of illuminated signs.

The sphere of usefulness covered by the "Elb-light" or "Pin Lamp" system is too extensive to admit of more than partial description in this paper. It consists essentially of a pair or several pairs of conductors of opposite polarity, made up of innumerable strands of very fine copper wire and properly insulated or incased in an outer covering consisting of a close-fibered "quick-healing" fabric or material. The lamps used have a special base, provided with two strong, sharp points or pins of sufficient length to pierce the outer and insulating covers of the conductors and make good contact with the conductors themselves; the fibrous adhesive qualities of the outer covering of the twin conductors being sufficient to hold the lamp securely in place once the pins are thrust into it as far as possible.

The conductors used in this system of lighting are provided in two distinct forms; one for use in producing signs, emblems, etc., the other especially adapted to the requirements of decorative lighting. For use in the class of work first mentioned, the insulated conductors in pairs of opposite polarity are flattened and closely packed, side by side, in regular rows upon a flat wooden surface, and secured in places by a strongly adhesive compound; they are then covered by a sheet of the fibrous material, which is similarly secured in places by an adhesive waterproof compound, and the edges of the board are inclosed. Into the surface of this signboard lamps are stuck, forming any character or outline desired. Upon removing the lamp the holes made by the pinlike contact points in the fibrous surface of the board immediately close up, effectually excluding moisture, and the arrangement of the pairs of concealed conductors in the board is such that if the contact points of the lamps are placed at right angles to the direction in which the pairs of conductors are laid, a circuit is certain to be closed through the lamp, no matter at what point the pins are inserted in the board. For use in decorative work the material used is the same, except that a single pair of conductors is used, each conductor being a cable, properly insulated and incased in the fibrous outer covering before referred to. These twin cables are extremely flexible and may be gracefully festooned or formed into any variety of fanciful outlines or figures, and the lamps attached by their pin contacts at such points as required to bring out the desired decorative illuminative effect. The extreme versatility of this system and the rapidity with which it can be installed render it of especial value in all forms of temporary decorative illuminations.

By means of this system of lighting a very novel effect was produced at the Metropolitan Opera House, in New York City, upon the occasion of the gala production of grand opera tendered to Prince Henry and his suite last winter, when the drop curtain used between the acts was composed entirely of rows of pendent cables thickly studded with low-candle-power lamps gleaming amid a mass of trailing smilax that effectually screened the stage from the view of the audience when the drop was down.

The contrast between the "Brewster" or "Link Receptacle" system and the "Elblight" system is quite marked, though both are designed to meet similar requirements. In the Brewster system a special receptacle is provided, which consists of two pieces: the receptacle proper, containing an ordinary Edison screw shell, and a porcelain contact cap arranged to engage contact pieces projecting through the bottom of the receptacle proper. The circuit wires are run through openings provided for that purpose in the contact cap, and it is then attached to the receptacle by means of a screw passing through the base of the receptacle into a nut imbedded in the contact cap, thus drawing the projecting ledge of the contact cap tightly into a corresponding groove in the bottom of the receptacle, making a practically watertight junction. The space between the wires and the holes in the contact caps through which the wires pass are then filled in with some adhesive waterproof compound, and a thoroughly watertight and safe construction is obtained. The re-

Link Receptacle Sign Construction

ceptacles themselves are linked together with S-shaped clamp-hooks, which bind firmly about the bottom of the receptacle, thus clamping any group of them into a rigid structure of any outline or design desired. The clamping S-hooks are made up in a variety of lengths, admitting of a space between receptacles of from three to twelve inches. In practice the receptacles are placed in the desired form and secured there by screwing up the S-shaped clamp hooks, after which the contact caps carrying the necessary wiring are attached. Owing to the fact that the contact caps are necessarily spaced at regular intervals, unless S-hooks of irregular lengths are used the same wiring may be repeatedly used though the grouping of the receptacles used be completely changed.

As an additional protection to the lamps and sockets when used in exposed positions out-of-doors, an aluminum rain-guard is provided. This rain-guard is adjustable upon the projecting shoulder of the receptacle proper, so that by moving it in or out it readily adjusts itself to the neck of an incandescent lamp of any size or shape, making a practically water-tight junction between the metal cap of the rain-guard and the bulb of the lamp.

Aside from the advantages of versatility and ready adaptability to the varied requirements of electric sign and decorative or spectacular work, the special advantage of this system is that it permits the use of practically any lamp having either a high or low candle-power, or large or small bulb; in addition to which it avoids the straggling, dangling appearance of the lamps usually prevailing in festoons, or similar decorative construction, where ordinary receptacles are used and merely attached to wires at once intended to supply current and support the lamps and receptacles.

For use in a more permanent class of construction this system is also well adapted, it only being necessary to provide a piece of sheet metal of the desired dimensions and outline in which holes are perforated to receive the receptacles. The clamping S-hooks are then put in place back of the metal surface, which thus conceals both the S-hooks and the wiring, producing a sign or emblem, which to all outward appearance is similar to standard sign construction, though considerably cheaper to produce; in addition to which, very little expense for labor is necessary to provide from the same material something entirely different.

On account of the comparatively slight amount of current consumed, and also because they afford means for putting a great deal of lettering in a small space, transparency signs of various types of construction have long been more or less popular. As a feature of attractiveness, however, the transparency can not compare with the notice-compelling surface-illuminated sign, which not only illuminates its own letters, but also serves to brighten and render more cheerful everything in its immediate vicinity. A great fault in the average transparency sign has also been that, through a false idea of economy, so few lamps are usually provided that the full value of the sign as an advertising medium is not obtained. In one respect, however, electric transparencies have a novel advantage over other types of illuminated signs. By using lamps of various colors, wired, each color upon a separate circuit and connected to a proper commutating switch, a great variety of color changes may be produced; the entire sign changing rapidly or slowly from one color or combination of colors to another, an effect impossible to obtain satisfactorily in any other type of sign.

As an adjunct to spectacular or sign lighting, commutating switches or flashers are often very valuable, and as their good qualities are becoming more generally realized they are becoming more and more popular. Not only is a great saving in current effected through the intermittent burning of the lamps in the sign, but to the minds of many advertisers a decidedly more novel and therefore more attractive result is obtained. Every one is probably more or less familiar with the various effects possible with these commutating switches, such as the flashing in and out of the letters of the sign one after the other, as if spelling the word, or the lighting of the lamps in a script sign one after the other in rapid sequence, making it appear as if an invisible pen were tracing the letters in lines of fire; also the illusion of constant waving that may be produced in an illuminated flag or the appearance of rotation that may be given to lamps mounted in a circle, etc., etc. Although an automatic flasher to produce these various effects often costs as much or more than the sign on which it is destined to operate, it will soon pay for itself as a result of its saving in current consumption alone, this saving usually amounting to from twenty-five to fifty per cent, depending upon the nature of the effect produced.

PRESIDENT-ELECT FERGUSON: These gentlemen will be glad to answer questions if you have any you wish to ask of them.

If there are no questions, I will announce that the invitation to the gentlemen in attendance at the convention to spend the remainder of the evening at the rooms of the Itannicnic Club has been accepted.

There will be a vaudeville performance and a general good time, and you are all invited to attend. A committee is waiting to escort you there.

(The meeting then adjourned.)

# ORDER OF BUSINESS

THURSDAY, May 22d, 1902.

## SEVENTH SESSION, 10 A. M.

1. Report—Committee on Standard Candle Power of Incandescent Lamps. DR. LOUIS BELL, Chairman
2. Paper—"The National Bureau of Standards." By DR. FRANK A. WOLFF, JR.
3. Paper—"Performance of Present 220-Volt Lamps." By F. W. C. BAILEY
4. Discussion—Rates. HENRY L. DOHERTY, LOUIS A. FERGUSON, E. F. PHILLIPS, L. R. WALLIS, RALPH J. PATTERSON, SAMUEL SCOVIL

## EIGHTH SESSION, 2 P. M.

1. Question Box
2. Rates (Continued)
3. Report—Committee on Resolutions. A. W. FIELD, Chairman
4. Report—Committee on Memorials. ERNEST H. DAVIS, Chairman
5. Topic—"Hot Water *versus* Steam Heating." J. F. PORTER, P. H. KORST, C. R. MAUNSELL, D. F. McGEE
6. Topic—"Are Free Lamp Renewals Desirable?" JAMES ENGLISH, F. ELLWOOD SMITH, F. W. LITTLE, W. J. GREENE, FRANCIS W. WILLCOX

7. Topic—"What Improvement Is Desired in Meters?" ROBERT FERRIS, CLIFFORD A. WHITE, H. H. SCOTT
8. Topic—"Liquid Fuel—Boiler Firing with Oil." JAS. W. WARREN, H. T. EDGAR
9. Paper—"Advantages of Gas Engines for Central-Station Work." By CHARLES H. WILLIAMS
10. Report—Secretary and Treasurer

## SEVENTH SESSION

President Doherty called the meeting to order at five minutes after ten o'clock, Thursday morning, and topical questions Nos. 17, 20 and 21 were considered, for which see Question Box.

THE PRESIDENT: We will now have the report of the committee on standard candle power of incandescent lamps.

Mr. James I. Ayer read the following report:

# REPORT OF COMMITTEE ON STANDARD CANDLE POWER OF INCANDESCENT LAMPS

MR. PRESIDENT AND GENTLEMEN: At the last convention your committee was authorized to arrange for the production of standardized incandescent lamps to be supplied to the members of the association for the purpose of testing.

Preliminary arrangements had been made to have this work done at Columbia University, but for various reasons it has seemed inadvisable to have your committee proceed actively with the work, especially as the National Bureau of Standards is preparing to do this and similar work in the very near future on a scale impracticable in a private institution.

At the time of the last convention, your committee felt that the association had better proceed to prepare its own standards, by reason of the probable delays that would occur in the organization and equipment of a government institution. It soon became evident, however, that, under the able and energetic administration of Dr. Stratton, the Bureau of Standards would actually be able to provide certified incandescent lamps, carrying greater weight as standards than any unofficial institution could hope to give, within a reasonably short time. It therefore seemed best to avoid the expenditure that would have been necessary to prosecute the work through that institution, and inasmuch as the Bureau of Standards is now substantially ready to take up the work of supplying lamps, your committee hereby recommends that the association shall adopt the certified standards of the National Bureau of Standards as the basis of rating for incandescent lamps.

With respect to the manner in which incandescent lamps shall be tested, your committee adheres to the opinion that, while in theory the mean spherical candle power should be the final test for luminous radiation of incandescent or other lamps until such candle power can be determined by more correct and precise processes than are now commercially available, it is best to depend upon the mean horizontal candle power, to be determined by rotating the lamp in the manner heretofore suggested and in general use. Obviously, such a measurement does not place lamps with all possible shapes of filament on a parity, but it does treat with substantial justice ordinary commercial incandescent lamps, and, moreover, it corresponds to the way in which other illuminants—competitors of the electric lamp—are habitually measured.

Cases will undoubtedly arise in which candle power in some specified direction may demand the consideration of the members of the association. In all cases where directed candle power—as contradistinguished from distributed candle power—is to be considered, the only possible way of placing various illuminants on a parity is to measure their intensity in the direction in which a specialized radiation is wanted, including in such measurement the effect of all devices intended to produce directed illumination, such as reflectors, special globes, and special positioning of the light-giving parts of the lamp with reference to intensity in particular directions. The great bulk of all lighting done by the members of the association is distributed lighting, and for this purpose your committee believes that the mean horizontal candle-power rating should be adhered to, while for the special problems of directed lighting all means for securing unusual intensity of illumination in some particular direction of the lamp ought to be included and placed on a parity. For example, rating a Nernst lamp—which is deliberately intended to give a downward hemispherical distribution—on its mean horizontal candle power would be manifestly unfair; while, if a lower hemispherical distribution is desired for any particular purpose, it would be equally unfair to deny to incandescent lamps the privilege of using reflectors or similar means of turning downward the luminous energy, which would otherwise not be radiated in the direction contemplated. In other words, your committee thinks that a logical distinction can be drawn, and should be made, between general and directed illumination. Lights designed for the former class of work can be conveniently measured in a single conventional zone, while in directed illumination the only fair programme is to compare lights on the basis of the directed beam which is desired for practical use.

Respectfully submitted,

Commttee, { LOUIS BELL, Chairman,
JAS. I. AYER,
C. W. RICE.

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THE PRESIDENT: Gentlemen, what will you do with the report?

MR. FERGUSON: I move the acceptance of the report.

(The motion was carried.)

The President: I take pleasure in introducing to the convention Mr. Frank A. Wolff, Jr., representing the National Bureau of Standards, who will explain the work they are trying to accomplish and the facilities at their command.

Dr. Wolff then addressed the meeting, describing the present work and future plans of the Bureau, as follows:

## THE NATIONAL BUREAU OF STANDARDS

In response to a widespread demand on the part of the scientific, educational, technical and manufacturing interests of the country, to which the National Electric Light Association also gave expression, Congress, on the very last day of the last session of the Fifty-sixth Congress, passed a bill establishing the National Bureau of Standards.

The functions of this Bureau are "to consist in the custody of the standards; the comparison of the standards used in scientific investigations, engineering, manufacturing, commerce and educational institutions with the standards adopted or recognized by the Government; the construction, when necessary, of standards, their multiples and subdivisions; the testing and calibration of standard measuring apparatus; the solution of problems which arise in connection with standards; the determination of physical constants and the properties of materials, when such data are of great importance to scientific or manufacturing interests and are not to be obtained of sufficient accuracy elsewhere."

" * * * The Bureau shall exercise its functions for the Government of the United States; for any state or municipal government within the United

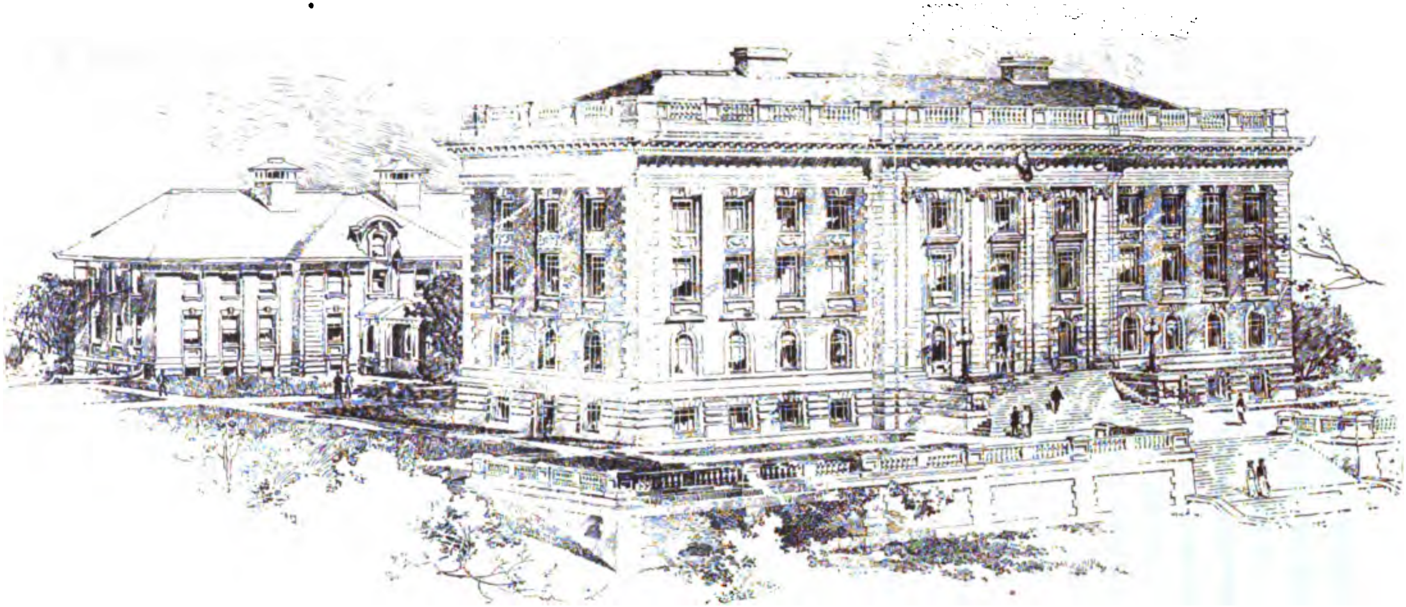
States; or for any scientific society, educational institution, firm, corporation or individual within the United States engaged in manufacturing or other pursuits requiring the use of standards or standard measuring instruments."

In view of the general interest manifested in the establishment of the Bureau, particularly on the part of the electrical fraternity, an invitation was extended by your honorable president to Prof. S. W. Stratton, its director, to give you a brief outline of its plans, and to give you some information in regard to the progress which has been made. Owing to the inability of Director Stratton to be present, I have been designated to appear in his stead.

The Bureau was formally organized July 1, 1901, after the scope and general plans had been thoroughly discussed with the members of the visiting committee and many others.

A beautiful site of seven and one-half acres, in the northwestern suburbs of Washington, was procured, within convenient access, but not too close to the car line to interfere seriously with any but the most precise measurements, which will, of course, constitute but a very small portion of the work to be undertaken. Moreover, this difficulty is easily surmountable by working after midnight when necessary.

The law appropriated $100,000 for a building, the cost of which was limited to $250,000. To meet the demands of manufacturing and technical interests for heavy testing work, and for experimental work requiring extraordinary facilities, a large and well-equipped power plant is required, and this makes necessary the erection of a separate power house at some distance from the main building. The elaboration of the numerous details of construction of the two build-



NATIONAL BUREAU OF STANDARDS

ings occupied a great deal of time, and as the work progressed its scope broadened, so that when the preliminary estimates of the cost of erection of buildings of the necessary size had been made by the supervising architect of the Treasury, under whom the buildings are to be erected, it was found impossible to construct them for the sum specified. An additional appropriation of $75,000 was therefore asked for, and has just been granted.

The main building, as shown in the accompanying illustration, will be four stories in height, approximately 150 feet long and 50 feet wide; and will contain about 50 rooms, all equipped with apparatus for verification work and for special investigations, and provided with gas, electric light, compressed air, suction, hot and cold water, as well as with a number of independent electric circuits, so that electrical currents of any desired character may be obtained.

The importance of temperature control in a physical laboratory has long been appreciated, and it is especially desirable in an institution where standardizing work is to be done, as nearly every result depends at least to some extent upon the temperature at which the measurements are made. Accordingly, means will be provided for closely regulating the temperature of any room at any desired temperature, both in summer and in winter, as will be more fully described below.

In most laboratories the basement, which on general principles would really be most suitable for precise measurements requiring the greatest stability and freedom from vibration, has to be devoted to the heating, lighting, ventilating and power plant, and to miscellaneous purposes. As a special power house is here to be provided, the basement of the main building, which is almost level with the ground and well lighted, will be utilized solely for the more precise work. Four of the rooms are to be fitted up as special-temperature rooms.

The basement will be vaulted over, so that the first-floor rooms will be almost as free from vibration as those on the floor below, and will therefore also be utilized for laboratory purposes.

The second floor will be set aside for the administrative and clerical work, for the library, and for the museum, in which standards and apparatus of historical importance will be preserved.

A well-equipped chemical laboratory will be fitted up on the third floor, part of which will accommodate a laboratory for photometric research. There will also be provided on this floor a lecture room with a seating capacity of 150 to 200. As it will be the policy of the Bureau to keep in close touch with the interests it serves, it is hoped that it may soon be in a position to extend invitations to scientific and technical associations to hold their meetings, from time to time, in Washington.

### THE MECHANICAL LABORATORY

The mechanical laboratory will be a three-story building, 135 feet long and 50 feet wide, and will contain the power and lighting plant, storage batteries, special alternating-current machines for experimental and testing purposes, the refrigerating plant, the heating and ventilating plant, auxiliary apparatus, the machine shop and carpenter shop, as well as laboratories for heavy electrical testing, photometry, gas and water-meter testing.

*Boiler Room*—In the boiler room two 125-hp boilers are to be installed, space being provided for doubling this capacity.

*Dynamo and Engine Room*—Two 80-hp high-speed engines, each direct-connected to two 25-kw direct-current generators, will be installed. Additional space will be provided for a unit of double this size as well as for the special alternators referred to below.

*The Heating and Ventilating Plant*—In the combined heating and ventilating system to be adopted, the air will be supplied to the various rooms by means of ducts, with the aid of electrically driven fans, the temperature of any room in either building being independently controllable by a thermostatic damper at the bottom of the respective flues, where the heated or artificially cooled air will be mixed with the air from without. The ducts are so proportioned as to permit a complete renewal of the air every 15 minutes. In winter the air to be heated will be passed over coils fed with exhaust steam, and in summer the air will be cooled by coils through which cooled brine is circulated.

*Refrigerating Plant*—To cool the air and to provide artificial ice, a refrigerating plant of 30 tons ice-melting capacity will be installed. Although the building will be used only a portion of the 24 hours, provision will be made for fully utilizing the refrigerating capacity, with the aid of a brine tank of sufficient capacity, the refrigerating machine being operated throughout the whole night when necessary.

*Instrument Shop*—The instrument shop, a most important adjunct to a modern laboratory, will be equipped with the latest types of motor-driven precision and engine lathes, milling machines, shapers, drill presses, etc. The shop has not yet been organized, but three or four mechanicians are provided for from July 1, 1902.

A liquid-air plant of sufficiently large capacity for all experimental purposes likely to arise, is also to be installed.

The auxiliary apparatus will consist of an exhaust fan for ventilating hoods, the storage-battery room, the toilet rooms, etc.; air compressors, vacuum pumps, pumps for circulating the hot and cold water, etc.

As the public gas mains are not yet laid as far as the site, a gas plant will also be installed.

A storage-battery room of considerable size is to be provided, and an adjoining room is to be fitted up for heavy current testing. Several of the rooms on the first floor will be used for experimental work, although, no doubt, as the work of the Bureau develops additional buildings will have to be provided, and the first of these will, in all likelihood, be an electrical laboratory. The mechanical laboratory will then be given up principally to power purposes and to the instrument shop. From present indications this contingency is likely to arise even before the buildings now planned are ready for occupation.

The third floor of the power house will, for the present, be devoted to gas and incandescent-lamp photometry, and to gas and water-meter testing.

The opinion has been expressed that the Bureau will not be ready to undertake verification work for some years, pending the construction and equipment of the buildings. Recognizing the importance of immediate work along a number of lines, temporary quarters have been secured in the Coast Survey Building, and arrangements are now being made to secure additional quarters near by. In these, apparatus will be installed and put in actual use as quickly as possible. Some of the work is already well under way.

One of the rooms has been fitted up for photometric purposes, and while the Bureau is not yet ready to verify incandescent lamps as photometric standards, the necessary apparatus has been delivered, or is about to be delivered, so that actual work can soon begin; and it is hoped that an announcement can be made within the next six months that photometric standards will be received for verification. Provision will be made for arc and Nernst-lamp photometry, as well as for the photometry of Welsbach and acetylene lamps and other commercial types. The Bureau will exert its efforts to provide for a practical means of determining mean spherical candle power at the earliest opportunity. The question of photometric standards will also receive consideration, it being recognized that, while the Hefner lamp is the best standard available, it is more than likely, judging from the researches at the Physikalisch-Technische Reichsanstalt, that a standard superior in every respect may soon be realized.

## THE VERIFICATION OF ELECTRICAL STANDARDS AND MEASURING APPARATUS

Pending the construction of primary mercurial resistance standards, a number of 1-ohm manganin coils have been adopted by the Bureau as preliminary standards of reference. The values of these are *certainly* known to within .002 per cent, in terms of the primary mercurial standards of the Reichsanstalt, and errors due to variations are avoided by periodic reverifications at that institution. The construction of primary mercurial standards and secondary mercurial standards will very shortly be undertaken.

The manganin standards of the Bureau, which range from .0001 ohm to 100,000 ohms, have been subjected to repeated inter-comparisons, the value of the multiples and sub-multiples of the units being determined in terms of the 1-ohm coils. The Bureau is thus equipped to undertake the verification of resistance standards, resistance boxes, potentiometers, ratio coils, shunt boxes and ammeter shunts, except, for the present, in cases where the resistance is to be determined when carrying large currents.

Facilities will shortly be provided for determining the specific conductivity of materials used for electrical conductors, and also for the determination of the tensile strength of such materials. Provision is also being made for the determination of insulation resistance, as well as dielectric strength and capacity of insulated wires and cables. The Bureau is prepared to receive for verification Clark and other types of standard cells, the values of which will be expressed in terms of the mean of about three dozen Clark cells which have been constructed at the Bureau.

The Bureau is also prepared for the verification of direct-current measuring apparatus of limited range, in limited quantity, milli-voltmeters and voltmeters up to 150 volts, ammeters up to 100 amperes; and arrangements are being made for increasing the range to 2,000 volts and 1,000 amperes, when direct-current wattmeters, watt-hour-meters, etc., will also receive attention.

Special facilities will be provided for alternating-current testing. The alternators for experimental and testing purposes will all be driven by direct-current motors operated from the generators, or, when necessary, from independent storage batteries. Thus, for investigating the influence of the higher harmonics on measuring instruments, condensers, transformers, arc lamps, etc., a set of motor-driven alternators, having relative frequencies of 1, 3, 5, 7, 9, 11, 13 and 15 times the base frequency, will be provided. All of these machines are to be connected to one shaft, and will be arranged so that the amplitude and phase of any component may be varied independently. The base frequency may be varied between 25 and 125; though for the latter frequency it will not be possible to work in the highest harmonics.

From this necessarily brief outline of the plans of the Bureau it will be seen that provision will be made for the verification of every type of measuring apparatus that the electrical engineer is likely to submit, and it is hoped that as soon as the buildings are completed the Bureau will be in a position to undertake for the National Electric Light Association, and for similar bodies, the solution of important technical problems requiring extraordinary experimental facilities, and to co-operate with them in every possible way within its proper scope.

Question No. 64 (for which see Question Box) was then taken up and discussed.

THE PRESIDENT: We will now proceed to the paper on the "Performance of Present 220-Volt Lamps," by Mr. Fred W. C. Bailey.

Mr. Bailey presented the following paper:

# PERFORMANCE OF PRESENT 220-VOLT LAMPS

The lack of reliable data on high-voltage lamps induced the writer to start a test which, as it progressed, grew in interest, and the results of which I have the honor and pleasure of presenting to this association. The test is as fair and accurate as it was possible to make it and the data are absolutely unprejudiced. The matter of publishing the results was not considered until the test was almost completed. I sincerely hope the data will be of service to you.

In response to the writer's request to two or three lamp makers for accurate data on the performance of their high-voltage lamps, some curves were received which were "beautiful to look upon," but doubts as to their accuracy were aroused by some rough readings taken from a few of the same makers' lamps that were burning in the engine room of a 220-volt plant. The necessary current for operating a test being granted the author by the owners of a 220-volt lighting plant—which was designed by the writer and which has several thousand lamps connected—this test was undertaken. The fourteen lots of lamps tested embrace practically every make of high-voltage lamps sold in this country six months ago.

The superior advantages of distribution afforded by the use of high-voltage lamps are largely counteracted in many cases by the excess of station capacity required. Mr. F. W. Willcox, at your last convention, presented very forcibly and clearly the position of the lamp relative to the station and the rapid increase of losses with a small decrease in the efficiency of the lamps. The performance of the 220-volt lamps on the market to-day leaves much to be desired on the question of efficiency and the average product sold is by no means high-grade, as will be revealed by a study of the accompanying curves and tables. The great improvement in the performance of the present leading lamps over those of two years ago furnished grounds for agreeable expectation along this line. Similar bases, bulbs, etc., being used in both low and high-voltage lamps, the physical qualities of the 220-volt lamps have kept pace with the improvements in the lower-voltage lamps. With the more extended use of high-voltage lamps, the demand for which is growing with great rapidity, will come a better-selected and more uniform product. The great lack of these qualities in the present average product is made very apparent by an inspection of the curves presented. Your attention has already been called to the advantage in selection afforded by the adoption of odd voltages such as 225 or 235 instead of 220, and also to the importance of close selection. Some makers are short-sighted enough to resort to the trick of overrating the candle power of lamps. The great majority of plants have no photometer and consequently cannot determine the real efficiency of their lamps. To take current and pressure readings of a few lamps and assume that they give sixteen candle power at their rated voltage, produces data of little or no value. Without candle-power measurements some lamps that are really very inefficient would appear to have a very fair efficiency. A photometer permanently set up in the plant stock room is just as valuable an apparatus as many others that are considered indispensable. Considerable attention is often given to the quality of fuel and plans for its economy. The quality of the lamps that eat up the coal pile deserves just as faithful attention, and it is much easier to check up accurately the latter end of the proposition than the former.

Lamps of 16-cp rating only were tested. The extremely delicate filament required in an 8-cp, 220-volt lamp of four watts per candle renders this lamp a much more difficult proposition than the 16-cp lamp. Within the last year the writer has used about one thousand 8-cp, 220-volt and 230-volt lamps and the comparatively yellow color of the light leads to the belief that they were really culled 10-cp to 12-cp lamps selected so as to afford about eight candle power at reduced voltage. There was a painful absence of that brilliant white light emitted from a filament operated at high temperatures. A good 8-cp, high-voltage lamp is an absolute necessity, on account of the increasing use of the lower-candle-power lamps.

### *Methods of Tests*

The lamps tested were obtained through supply houses, at least fifty lamps being obtained of each make, and every lot consisting of two separate orders placed through different firms. More than fifty lamps were purchased from several makers, and from these lots fifty lamps were selected at random from the package and set aside for test. The test bank was located in a large, well-ventilated room adjoining the lighting plant, and the photometer was set up in the room occupied by the bank; the room being rendered dark, during candle-power measurements, by means of heavy card board placed over the openings. The card board was in turn covered with black bunting to prevent reflection. The bank consisted of a row of fourteen vertical strips of twelve lamps each, the sockets being placed ten inches from centre to centre. The sockets were standard Edison base, keyless receptacles and the bank wiring consisted of No. 10 B. & S. G. bare copper. The maximum difference between any two sockets on the bank was .02 of a volt. Each lot of lamps was placed on an independent strip and a recording voltmeter was mounted at the centre of the bank. A special feeder was run from the dynamo switchboard to the bank and the pressure wire was connected from the centre of the bank to a Weston illuminated-dial potential indicator, reading 180 to 260 volts, which was mounted on the dynamo switchboard and by means of which the pressure on the bank was regulated. This instrument was recalibrated at the beginning of the test and was standardized at the beginning of each one-hundred-hour period of the life test. The lamps operated on the life test were returned, after each reading, each to its proper socket on the bank. The lamps throughout the test were burned in a horizontal position and the current was maintained continuously upon the bank from one set of readings to the next. The majority of the lamps showed very little drooping of the filaments, the distortion being most marked in lots D, L, E, K and M. The candle-power measurements were made with a standard Deshler-McAllister photometer, equipped with a rotating stand and fitted with an oil standard, which was checked at every sixth lamp reading. The oil standard proved very satisfactory, thirty-five to forty-five lamps being frequently measured without changing the adjustment of the standard lamp. Ample time was taken in the first adjustment of the standard lamp, forty or fifty minutes being required. The photometer scale was calibrated from seven to 32 candles and all lamps reading less than 8.5 candles were remeasured, using an eight-candle-power standard, which of course gave the scale divisions one-half their normal value. The lamps tested were rotated at 190 revolutions per minute. In reading the photometer, a card was placed over the pointer and scale and the spot box was shifted from left to right until a balance was obtained, the reading being noted by an assistant. The card was again placed over the pointer and scale and the spot box shifted from right to left until a balance was obtained. The two readings were carefully checked and in no case were they permitted to differ more than one-tenth candle power. This method avoids the natural tendency of the operator to glance at the scale and compels complete dependence upon the judgment of the spot box in checking the two readings made of every lamp. The pressure on the lamp under test was carefully adjusted before each of the two readings and was again checked after the second reading. Two current readings were taken of each lamp, one at the first adjustment of pressure and one when the pressure was checked. The candle-power readings were taken from lamps selected at random from the various lots instead of completing the readings of each lot separately. This procedure would distribute among the various lots any slight temporary error in the candle-power standard. The watts were determined by means of a voltmeter and milli-ammeter, the former being readable to one-fifth of a volt and the latter readily readable to one-half milli-ampere. Both instruments were of Weston make, were calibrated at the beginning of the test and were recalibrated and compared with standards several times during the progress of the test. The readings of all lamps at each point in the life test were made on the same day and all photometer readings were made by the same operator. The same instruments were used throughout the test.

*Target Diagrams*

The lamps of each of the various lots were numbered one to fifty and were tested for wattage and initial at rated voltage, and the results were plotted on the target diagrams which are no doubt familiar to all. The horizontal sides of the oblong target represent a limit one and one-half candles above and below the normal rating. The vertical sides of the oblong target represent a limit of three watts above and below the normal. The diagonal lines passing through the centre of the oblong targets represent the normal-rated watts per candle of the lot and on either side of this diagonal line is another, running almost parallel, which represents a limit of one-half watt per candle above and below the rating. The centre of the target in every case represents the manufacturer's rating of the lamps and the dots inclosed by the circle and crossed by the short division lines represent the average result of the entire lot of fifty lamps. Lamps whose readings occur on the limit lines of target are counted as being inside of the same. The diagonal form of target, which I believe was first used by a western lamp manufacturer, is, in the writer's opinion, superior to the ordinary oblong target, as lamps in the upper left-hand corner and lower right-hand corner of the oblong target differ almost .5 watt per candle from the rating. The diagonal target is made by omitting the triangular space in the upper left and lower right-hand corners of the oblong target. These triangular spaces are formed by the watt-per-candle limit lines crossing the corners of the oblong target. Well-selected lamps should have at least 80 per cent of LAMPS within a target limiting the candle power to one and one-half candles above or below the normal rating and the watts per candle to one-quarter watt above or below the rating. The table in Figure 15 gives the percentage of lamps coming within the oblong target and also the percentage coming within the diagonal target. The table also lists the average actual candle power, the rated watts per candle and the actual watts per candle of each lot on the targets. The target diagrams are shown in Figures 1 to 14 inclusive.

Preliminary test of lot A in Figure 1 shows the average of the initial readings outside the target. The lamps are widely scattered, ranging in candle power from 11.7 to 16 and from 55.3 to 67.1 watts. The lot as a whole is very low in candle power and efficiency.

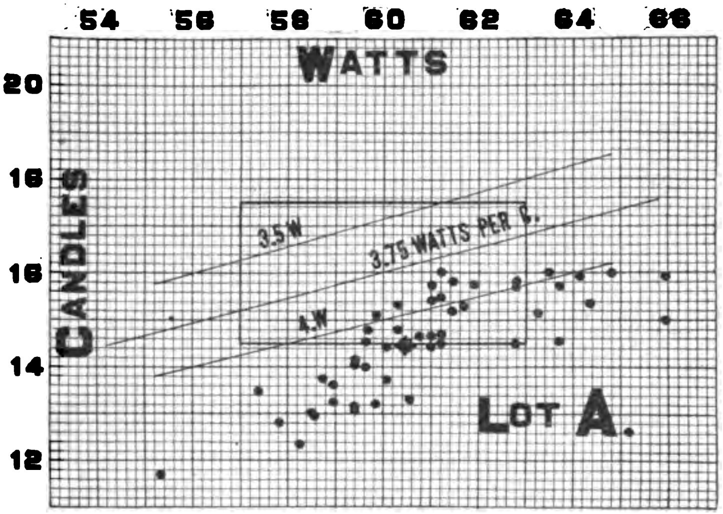
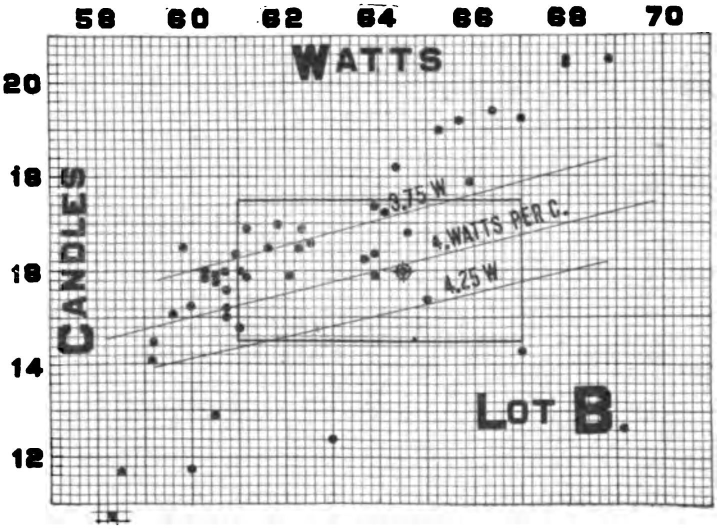


Fig. 1—Target Diagram of Lot A

Lot B preliminary, shown in Figure 2, has the average initial very close to the maker's rating, but the lamps are very badly scattered, ranging in candle power from 8.25 to 20.5 and from 54.5 to 68.87 watts. This target shows an utter lack of care in selection of lamps.

Target of lot C in Figure 3 shows lamps averaging close to rating but a trifle high in candle power. The diagram, however, is typical of a well-selected lamp, the bulk of the lamps being well bunched about the average. Lamps range in candle power from 14.36 to 18.73 and from 59.2 to 63.9 watts.



● 8.25 C.P. - 54.5 WATTS

Fig. 2—Target Diagram of Lot B

Preliminary of lot D in Figure 4 shows a well-selected lamp, the average being very close to the rating. The lamps range in candle power from 13 to 19.1 and from 60.75 to 67.5 watts.

Preliminary test of lot E in Figure 5 shows a very scattered lot of lamps which average near the rated efficiency but are low in candle power. The average, and practically the entire lot, are well outside the target. The lamps vary in candle power from 11.23 to 18.6 and from 50.06 to 61.85 watts. The target shows no attempt at selection, as some lamps of practically the same candle power vary about 11 watts.

Preliminary test of lot F in Figure 6 shows a scattered lot of improperly rated lamps which are very poorly selected, as lamps of nearly the same candle power vary greatly in efficiency. The average dot and all lamps are far removed from target. The lamps vary in candle power from 8.8 to 12 and from 55.35 to 63.27 watts and average over 5.5 watts per candle.

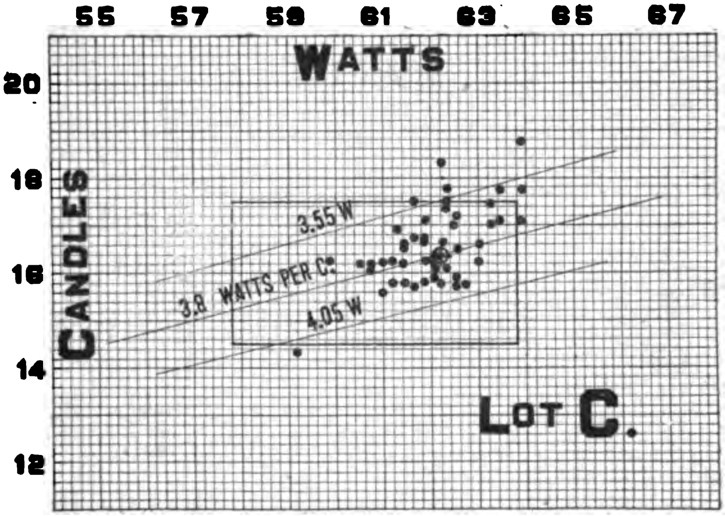


Fig. 3—Target Diagram of Lot C

Target of lot G in Figure 7 shows the average dot and the majority of lamps outside the target. The lamps are incorrectly rated, though fairly uniform and near the rated efficiency, but are high in candle power, ranging from 14.5 to 18.6 candles and from 64.8 to 69.75 watts.

Preliminary test of lot H in Figure 8 shows lamps low in candle power and of very low efficiency. The lamps range in candle power from 12.68 to 16.13 and from 62.53 to 71.35 watts. The average of lot is barely inside of target.

Target of lot S in Figure 9 shows lamps of a fair degree of uniformity but low in candle power. The candle power ranges from 13.18 to 16 and the watts from 57.1 to 63.4. The average and majority of lamps are outside of target. Lamps are not properly rated.

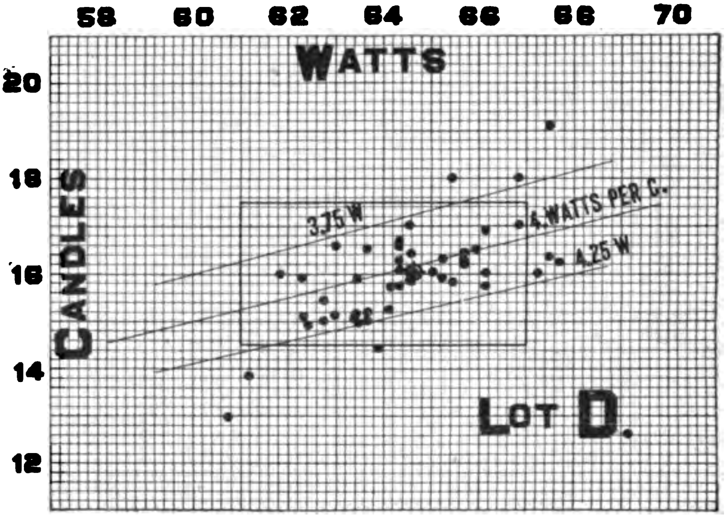


FIG. 4—TARGET DIAGRAM OF LOT D

Preliminary test of lot J in Figure 10 shows a fair degree of uniformity, the average candle power being very close to rating and the efficiency somewhat better than rating. The candle power ranges from 13.6 to 17.25 and the watts from 55.17 to 63.97.

Preliminary for lot K in Figure 11 shows a great lack of uniformity and a wide range in candle power and efficiency. The lamps vary from 14 to 18.8 candle power and from 57.17 to 69.43 watts. The average efficiency is practically as rated, but the average candle is somewhat below rating.

Target of lot L in Figure 12 shows a somewhat scattered lot of lamps which are quite low in candle power. The average dot and great majority of lamps are outside of target. The candle power ranges from 12.65 to 17.4 and the watts from 56.9 to 64.15.

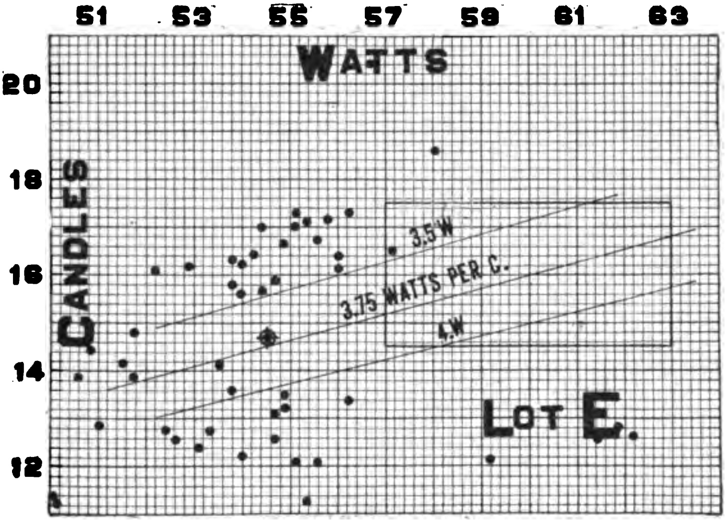


Fig. 5—Target Diagram of Lot E

Diagram of lot M in Figure 13 shows a very wide range in candle power and comparatively low efficiency; the candle power varying from 13.1 to 20.4 and the watts from 61.9 to 69.6.

Preliminary of lot N in Figure 14 shows a very high degree of uniformity and lamps of high efficiency.

The average candle power is very close to rating and the efficiency is somewhat better than rating. The lamps range in candle power from 14.8 to 16.8 and the watts from 49.95 to 55.8.

| Lot | Rated Initial c.p. | Average Actual Initial c.p. | Rated Initial Watts per c.p. | Actual Average Initial Watts per c.p. | Percentage of Lamps within Oblong Target | Percentage of Lamps within Diagonal Target |
|---|---|---|---|---|---|---|
| A | 16 | 14.44 | 3.75 | 4.186 | 40 | 20 |
| B | 16 | 15.97 | 4. | 4.038 | 32 | 14 |
| C | 16 | 16.37 | 3.8 | 3.83 | 86 | 84 |
| D | 16 | 16.08 | 4. | 4.02 | 80 | 80 |
| E | 16 | 14.7 | 3.75 | 3.70 | 2 | 0 |
| F | 16 | 10.6 | 4. | 5.63 | 0 | 0 |
| G | 16 | 17.08 | 4. | 3.95 | 36 | 36 |
| H | 16 | 14.6 | 4.2 | 4.64 | 50 | 14 |
| I | 16 | 14.7 | 4. | 4.09 | 32 | 30 |
| J | 16 | 15.94 | 3.75 | 3.67 | 76 | 68 |
| K | 16 | 15.48 | 4. | 4.08 | 40 | 30 |
| L | 16 | 14.36 | 3.75 | 4.16 | 30 | 8 |
| M | 16 | 15.5 | 4. | 4.22 | 48 | 28 |
| N | 16 | 15.95 | 3.4 | 3.29 | 86 | 86 |

FIG. 15—RESULTS OF TARGET DIAGRAMS

### *Life Test*

The twelve lamps of each lot that were operated on the life test were selected as closely as possible to the rated candle power and efficiency. This careful selection of lamps grants an advantage not due them to the lamps that were poorly selected at factory, and undoubtedly shows more uniform results on the life curves than if they were selected at random. It is difficult to see, however, how more erratic performance could be obtained than is shown on some of the curves presented, even though lamps be taken at random. Readings of each lot were taken at 25, 50 and

100 hours and at the expiration of each 100-hour period and thereafter, up to and including 1,500 hours. The regulation of pressure on the bank of lamps was well within one per cent and lamps were operated at normal rated voltage. In taking the candle-hour measurements a maximum of one-half candle rise from the initial was read, thus cutting off the peak of freak curves showing an abnormal rise in candle power.

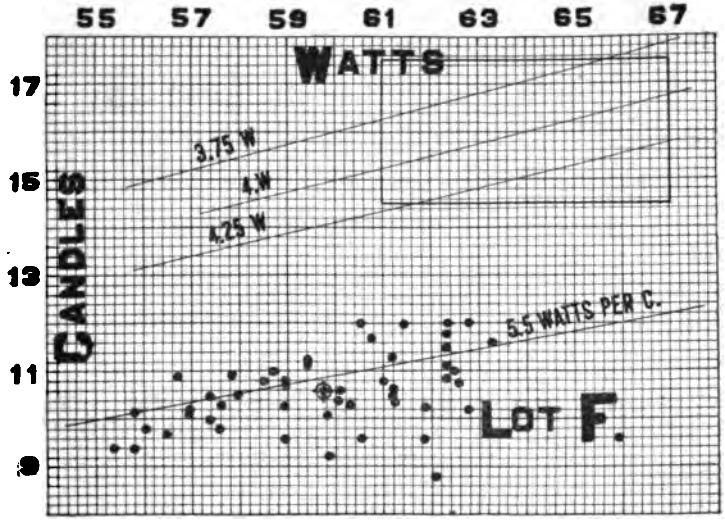


FIG. 6—TARGET DIAGRAM OF LOT F

The candle-hour area was determined to the 80-per-cent limit and a separate reading was taken from the 80-per-cent limit to the 1,500 hour mark, or until the burning out of the lamp. These separate readings are tabulated in Figure 32. The candle-hour-area readings from the life curves were taken by means of a Crosby planimeter, which was accurate within one part in one thousand. Candle-hour readings were taken of each individual lamp of each lot.

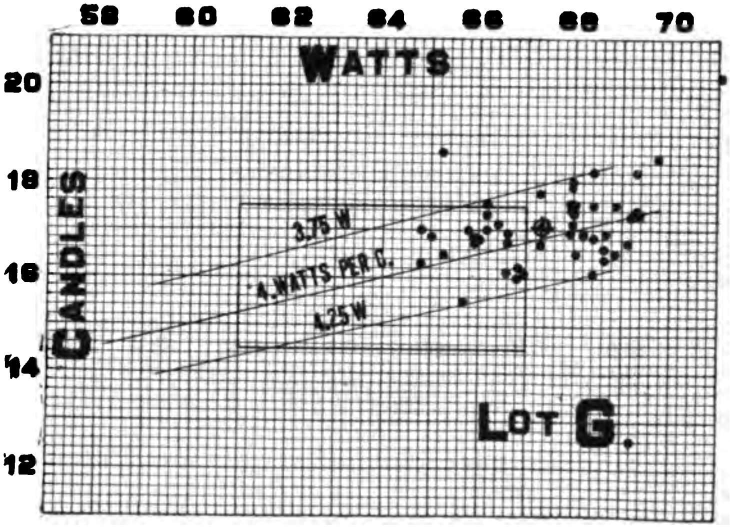


FIG. 7—TARGET DIAGRAM OF LOT G

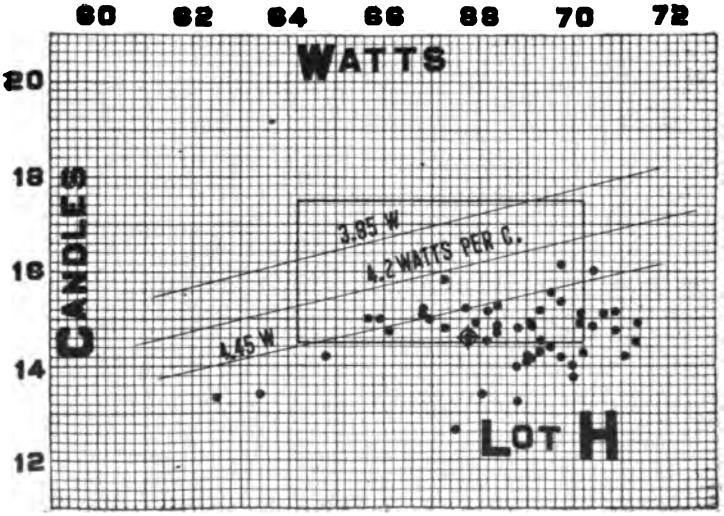


FIG. 8—TARGET DIAGRAM OF LOT H

| Lot | Life in Hours at which Average c.p. of Lot Declined to 80% of Initial c.p. | Average Candle-Hour Area During Useful Life | Total Average Candle Hours During Test of 1,500 Hours |
|---|---|---|---|
| A | 635 | 9,023 | 15,758 |
| B | 20 | 696 | 11,507 |
| C | 620 | 8,870 | 19,211 |
| D | 638 | 9,046 | 14,202 |
| E | 234 | 3,412 | 12,920 |
| F | 1,210 | 10,796 | 11,757 |
| G | 708 | 11,012 | 20,917 |
| H | 1,109 | 12,342 | 12,542 |
| I | 567 | 6,692 | 11,644 |
| J | 562 | 7,879 | 16,751 |
| K | 525 | 4,775 | 6,659 |
| L | 47 | 1,384 | 7,386 |
| M | 620 | 6,516 | 14,778 |
| N | 467 | 6,545 | 10,892 |

FIG. 32—TABLE OF CANDLE-HOUR AREAS

The life curves for the various lots are shown in Figures 16 to 29 inclusive.

Life curves of lot A shown in Figure 16 start with an average initial candle power of 15.84, the lamps varying from 16 to 15.7 candles. Notwithstanding this very close selection of lamps the individual curves diverge somewhat widely and at fifty hours show a range in candle power of from 13.05 to 16 candles. Lamps are not of very uniform quality. The lot declines to 80-per-cent limit at 635 hours. The average candle-hour area of the lot, above the 80-per-cent limit, is 9,023 and from the 80-per-cent limit to 1,500 hours is 6,735.

In Figure 17 are the life curves of lot B, which show a typical low-grade lamp. The average initial of lamps is 16.09 and the range in initial candle power of lamps selected is from 16.8 to 15.4. The average of the lot declines to 80-per-cent line in about twenty hours and

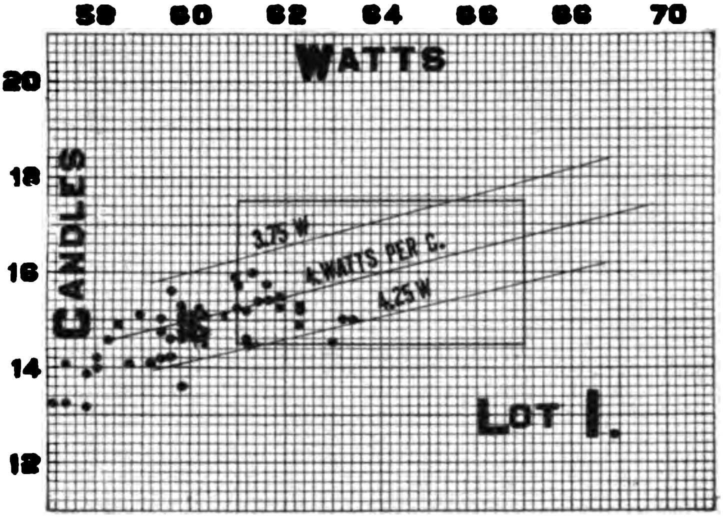


FIG. 9—TARGET DIAGRAM OF LOT I

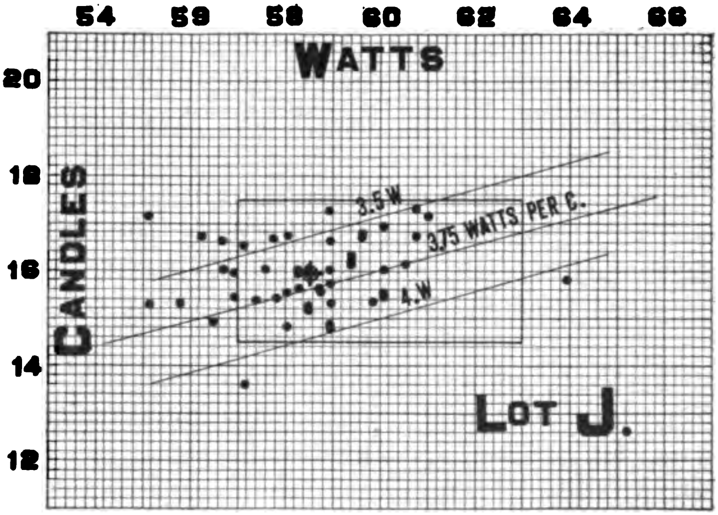


FIG. 10—TARGET DIAGRAM OF LOT J

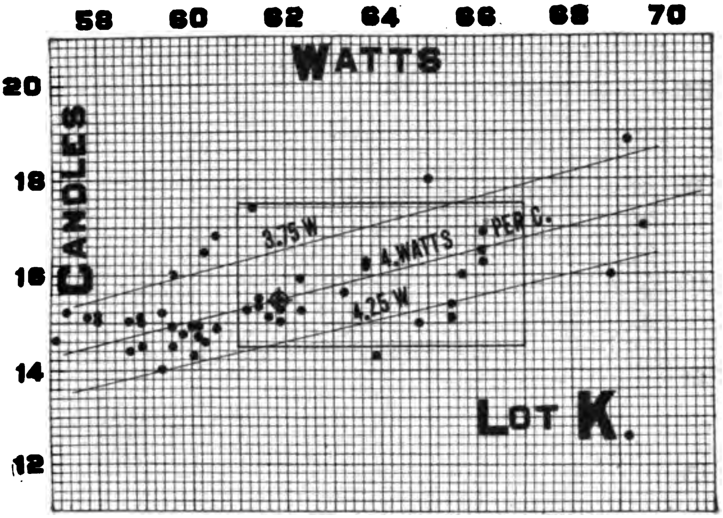


FIG. 11—TARGET DIAGRAM OF LOT K

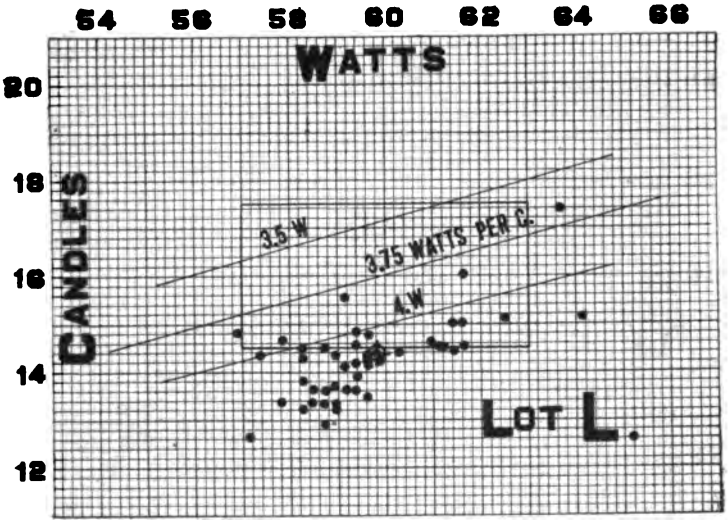


FIG. 12—TARGET DIAGRAM OF LOT L

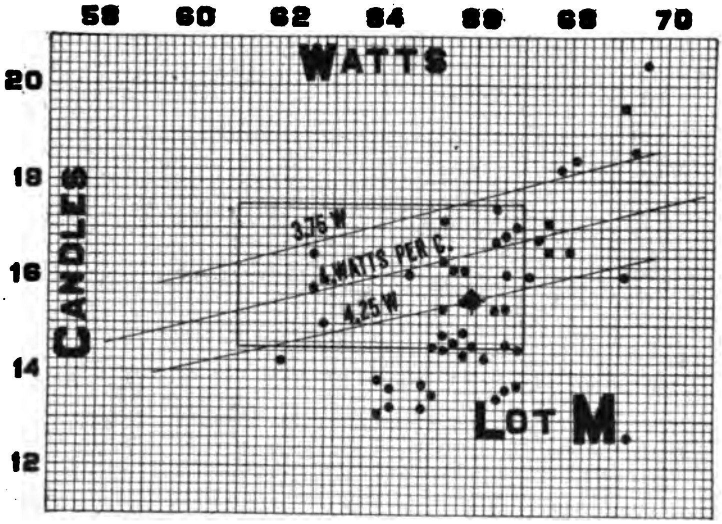


FIG. 13—TARGET DIAGRAM OF LOT M

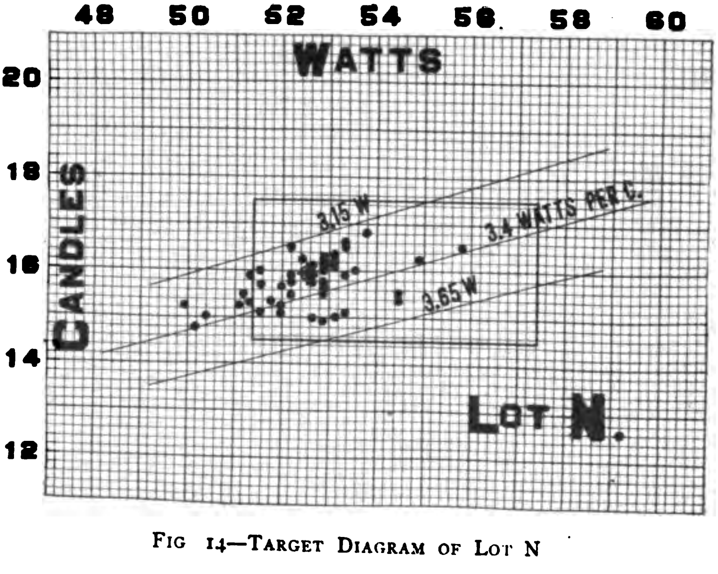


FIG 14—TARGET DIAGRAM OF LOT N

to about 67 per cent of initial at fifty hours. This lot is of very poor manufacture and the wide spread of individual curves shows an utter absence of uniformity. The average candle hours above the 80-per-cent limit is 696 and the average from 80-per-cent limit to 1,500 hours is 10,811.

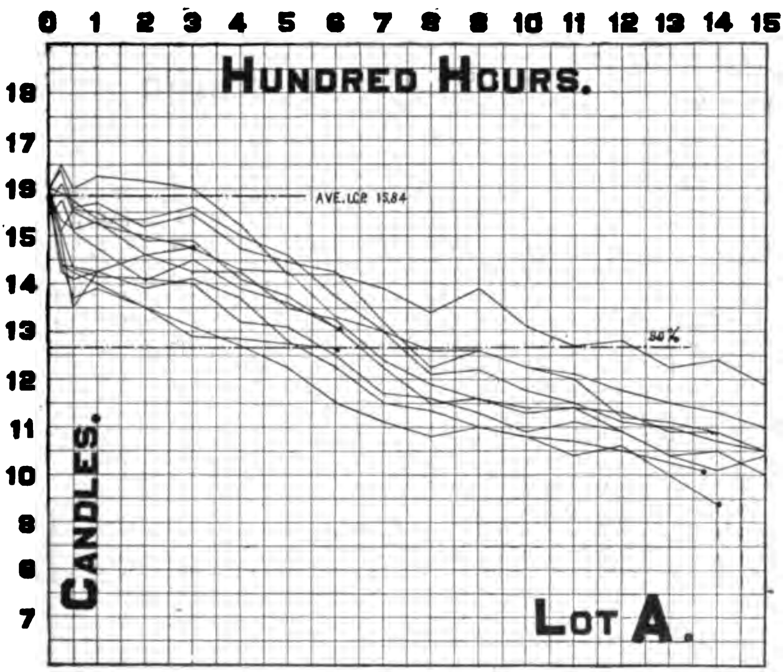


FIG. 16—LIFE CURVES OF LOT A

In Figure 18 are the life curves of lot C, which are typical of very uniform and high quality, the individual curves following each other very closely. The variation from highest to lowest is within one candle for practically the entire course of curves and the average rise in candle power is only .55 of one per cent. The average initial is 16.16 candle power, the lamps ranging from 16.6 to 15.75 candle power. The lamps decline to 80-per-cent limit in 620 hours. The average candle-hour area above 80-per-cent limit is 8,870 and from 80-per-cent limit to 1,500 hours is 10,341.

Life curves of lot D, shown in Figure 19, start

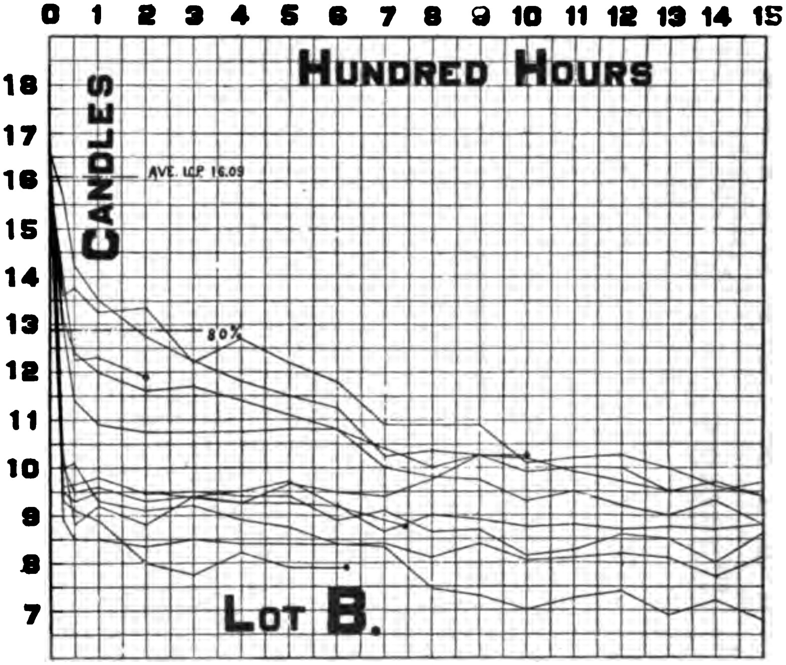


Fig. 17—Life Curves of Lot B

with an average initial candle power of 15.98, the lamps ranging from 16.3 to 15.9 candle power. The lot is only fairly uniform, the range at 100 hours being from 14.75 to 17.2. The average candle power declines to the 80-per-cent limit at 638 hours. The value of candle-hour area above the 80-per-cent limit is 9,046 and from 80-per-cent limit to 1,500 hours is 5,156.

Curves of lot E, shown in Figure 20, indicate very poor lamps, which decline to the 80-per-cent limit within 234 hours. The average initial is 16.04 candle power, the lamps varying from 16.75 to 15.65 candles.

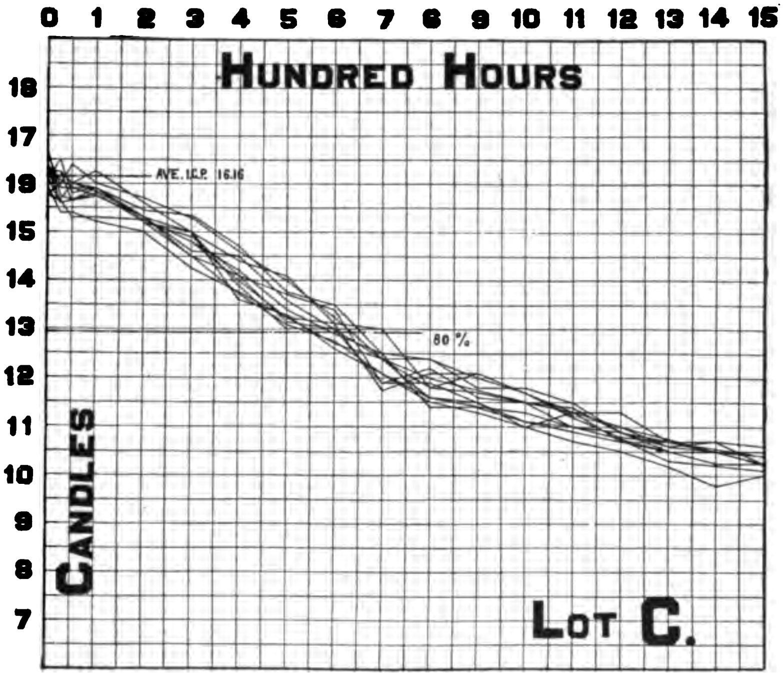


FIG. 18—LIFE CURVES OF LOT C

With this close initial range the curves diverge widely, and at 100 hours the lamps vary from 16.25 to 11.2, showing that lamps are not at all uniform. The candle-hour area above 80-per-cent limit is 3,412 and below is 9.512. The average initial efficiency of this lot is quite high, i. e., 3.39 watts per candle.

In Figure 21 are life curves of lot F, which show comparatively little drop and do not decline to 80 per cent of their initial until 1,210 hours; but this is to be expected when lamps are of such low efficiency, i. e., 5.3 initial watts per candle. The lamps are fairly uniform but not correctly rated. The average initial is only 11.54 and lamps selected for life test varied from 12 to 11.25 candle power. The candle-hour area above 80-per-cent initial candle power is 10,796 and from 80-per-cent limit to 1,500 hours is 661.

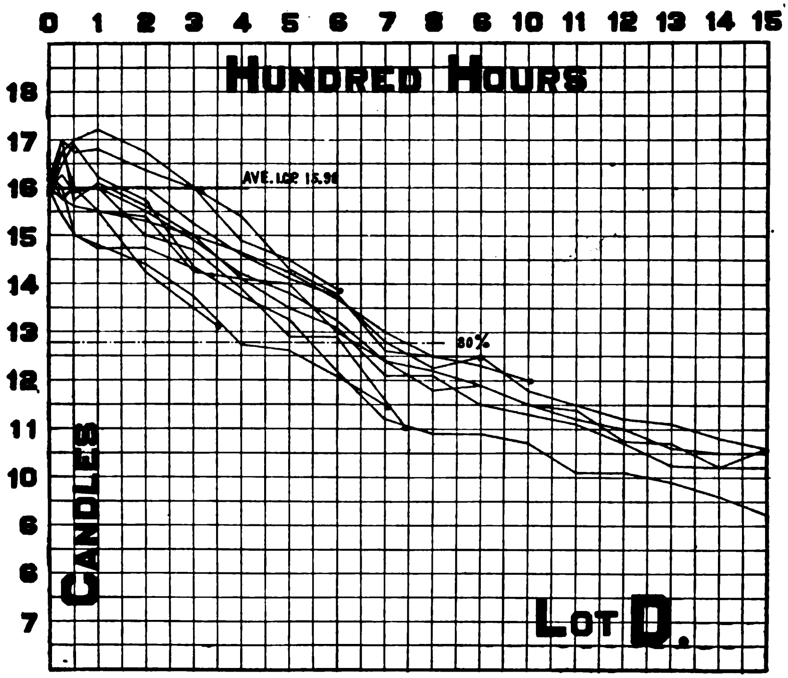


FIG. 19—LIFE CURVES OF LOT D

Life curves of lot G, shown in Figure 22, display a uniformity of product above the average and also show a marked rise in candle power. The average initial is 16.43 candle power, the lamps varying from 15.5 to 16.8. The lot declines to 80 per cent of the initial candle power in 708 hours. The average value of candle-hour area above the 80 per cent limit is 11,012 and from 80-per-cent limit to 1,500 hours is 9,905.

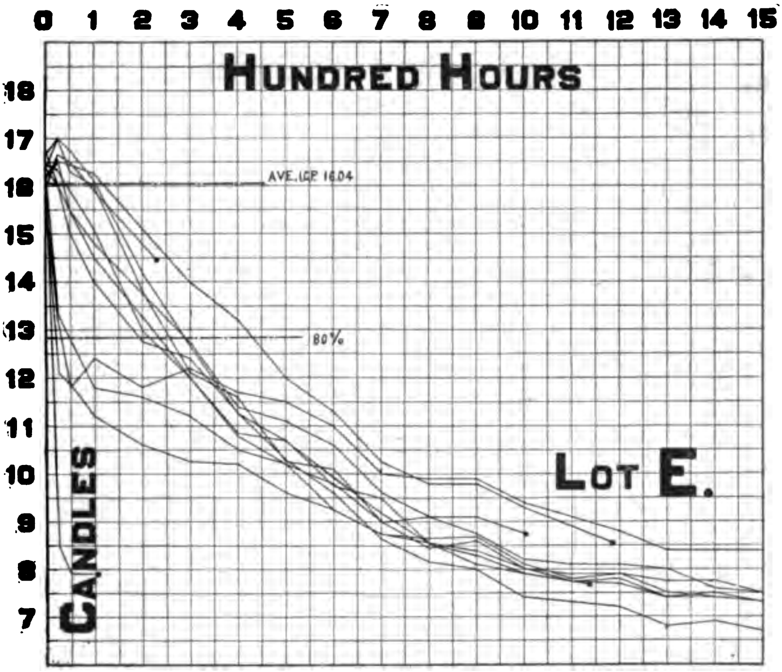


FIG. 20—LIFE CURVES OF LOT E

In Figure 23 are the curves of lot H, which show a very well sustained line, especially for the first 300 hours. This is to be expected, however, from a low-efficiency lamp, i. e., 4.45 watts per candle. The average initial is 15.12 candle power, the individual lamps ranging from 14.8 to 16.15. The average candle hours per lamp above the 80-per-cent limit is 12,342 and from 80-per-cent limit to 1,500 hours is 200.

The average of lot declines to 80-per-cent initial in 1,109 hours.

Curves of lot I, shown in Figure 24, follow each other closely, indicating a uniform product. The rise in candle power is rather marked. The average initial is 15.48 candle power, and the lamps vary from 16 to 15.1 candles. The average of lot declines to 80 per cent of initial candle power in 380 hours, but the burning out of one lamp at 305 and one at 306 hours raises the average of lot above the 80-per-cent limit

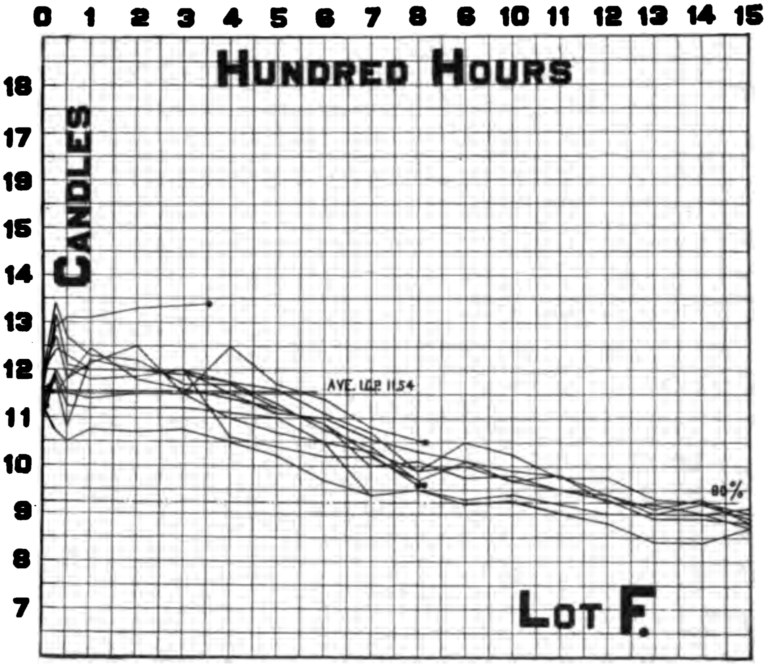


FIG. 20—LIFE CURVES OF LOT F

line, though average declines below the line again at 567 hours. The lamps burning out being below the average of the lot, of course raises the average figure; see average candle curves of each lot. The average value of candle-hour area above the 80-per-cent limit is 6,692 and below the 80-per-cent limit is 4,952.

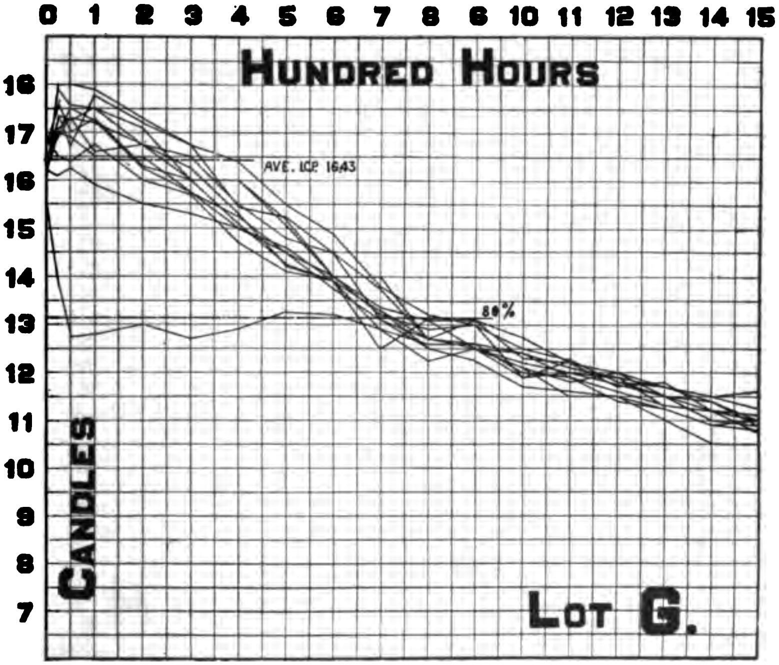


FIG. 22—LIFE CURVES OF LOT G

Lot J curves, shown in Figure 25, exhibit a fair uniformity of performance. The average initial is 16.25 candle power, the lamps ranging from 17.2 to 15.8 candle power. The lot declines to 80-per-cent limit in 562 hours. The average value of candle-hour area above the 80-per-cent limit to 1,500 hours is 8,872.

In Figure 26 are the curves of lot K, which show very erratic performance of a lot of low-grade lamps. The average initial is 15.81 candle power, the lamps ranging from 15.25 to 16.25 candle power. The individual lamp curves diverge very widely and the frequent burnouts show a poor and irregular product.

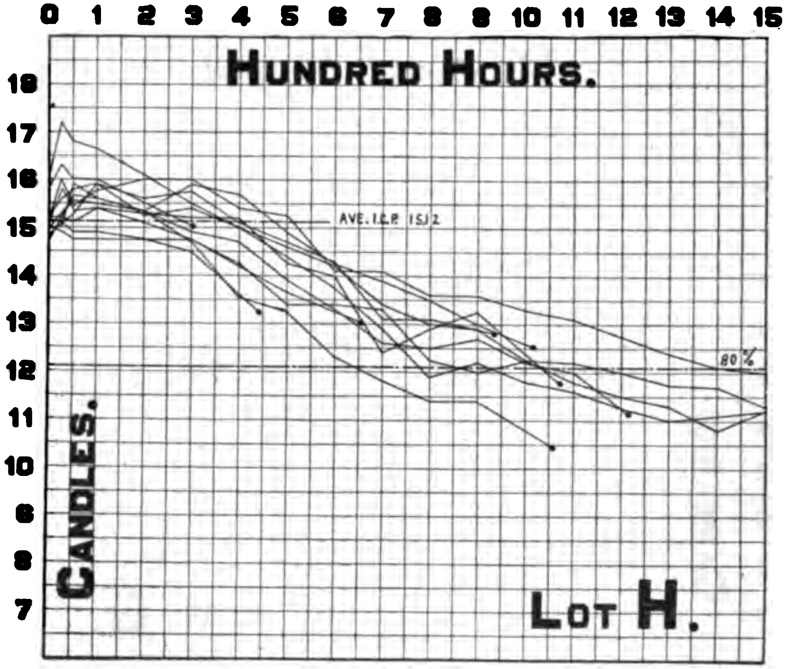


FIG. 23—LIFE CURVES OF LOT H

The average of lot declines to 80 per cent of initial in 525 hours. The average candle-hour area above 80 per cent is 4,775 and below limit is 1,884.

The lot L life curves in Figure 27 show a group of lamps which, to use a slang expression, are certainly "bad actors." The variety of curves afforded by this lot of lamps would lead one to believe the lamps were made in the dark. The average initial is 15.15 candle power and the twelve individual lamps vary from 17.4 to 14.5 candle power, this being as good a selection as could be obtained. The average candle power of lot declines to 80 per cent of initial

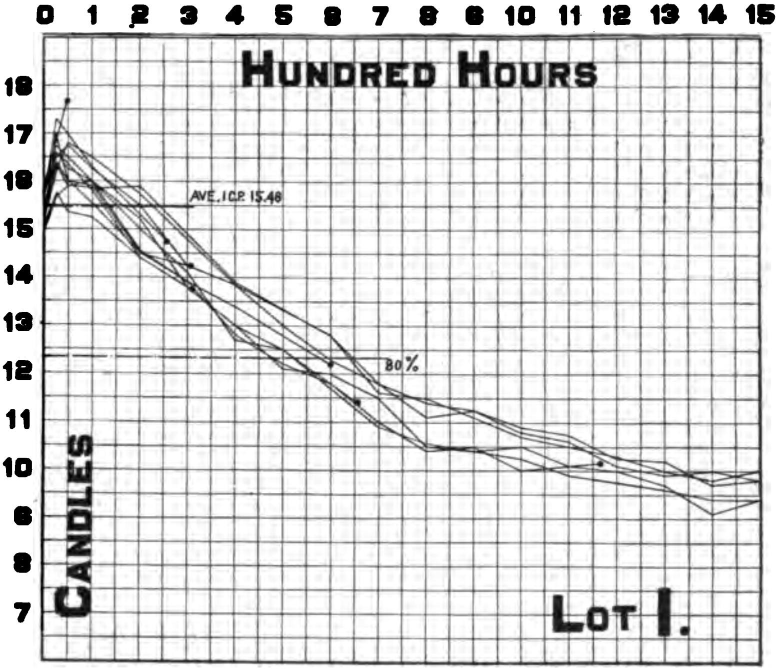


FIG. 24—LIFE CURVES OF LOT I

in about forty-seven hours. The average value of candle-hour area above 80-per-cent line is 1,384 and below 80-per-cent limit is 6,002.

In Figure 28 are the life curves of lot M, which show a great lack of uniformity. The average initial is 16.08 candle power, the individual lamps varying from 16.8 to 15.3 candle power. From this comparatively close selection of lamps the curves diverge, and at fifty hours the lamps range from 16.45 to 11.45 candle power. The average of lot declines to 80-per-cent limit in 620 hours. The average candle-hour area above 80-per-cent limit is 6,516 and below is 8,262.

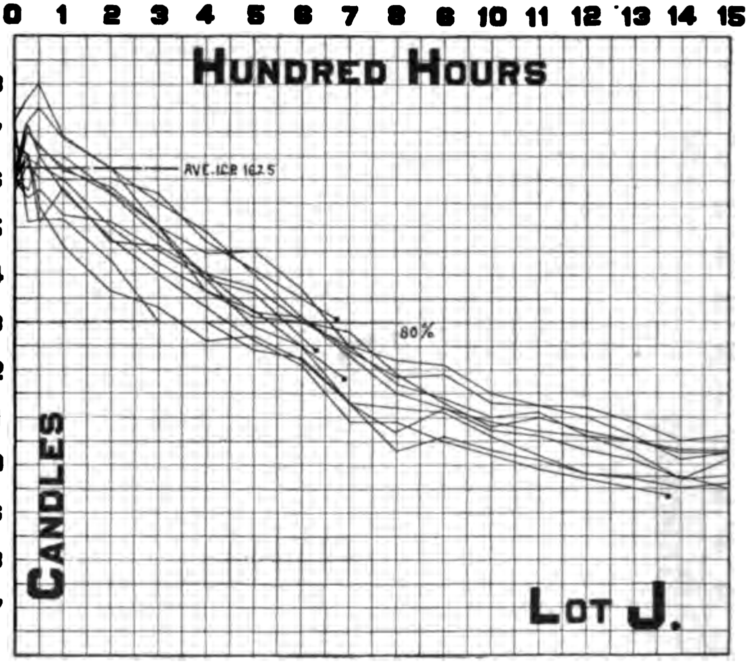


FIG. 25—LIFE CURVES OF LOT J

The life curves of lot N, shown in Figure 29, display the performance of a uniform lot of lamps having a somewhat rapid decline in candle power. Considering the high efficiency at which lamps operated, the curve is very satisfactory. The average initial candle power is 16.03 and the individual lamps vary from

16.6 to 15.1 candles. The average candle-hour area above 80-per-cent limit is 6,545 and from 80-per-cent limit to 1,500 hours is 4,347. The lamps decline to 80 per cent of the initial candle power in 467 hours.

*Average Curves*

From the individual life curves of each lot was plotted a curve showing the average value of each lot. The average candle-power curves are shown in Figure 30 and the average watts-per-candle curve of each lot is shown in Figure 31. The cause of the sudden and pronounced peaks and dips in the average curves, you will find by reference to the

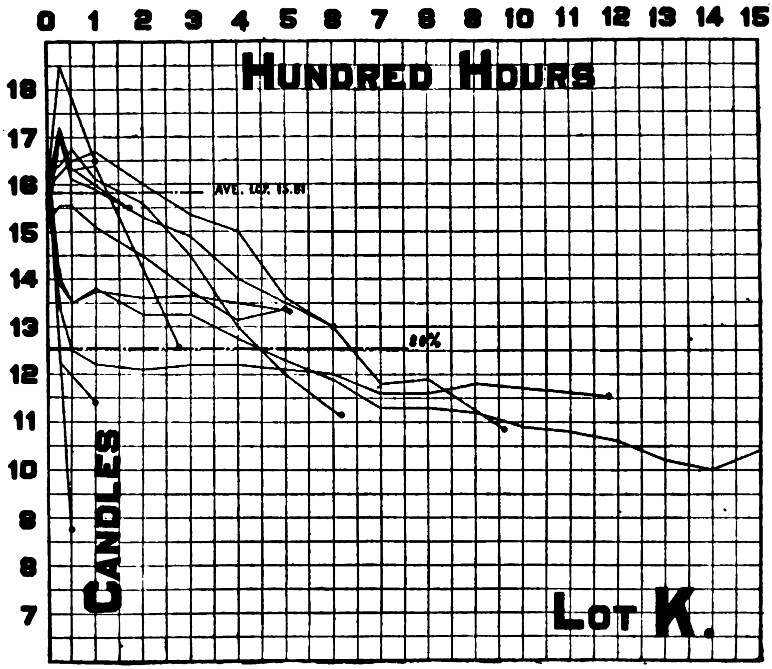


FIG. 26—LIFE CURVES OF LOT K

individual life curves for the particular lot whose average curve is under consideration. The burning out of a lamp that is low in candle power as compared with the average of the lot, will, of course, cause a sudden rise in the average candle-power curve of the lot. Again, if a lamp burns out which is operating at a comparatively high efficiency, the average wattage curve of the lot will drop. This drop or rise is not accurately shown by the average curves, for if the irregular lamp burns out at, say, 450 hours, or midway between the 400 and 500 readings, the curve, to show the result accurately, should rise vertically to the

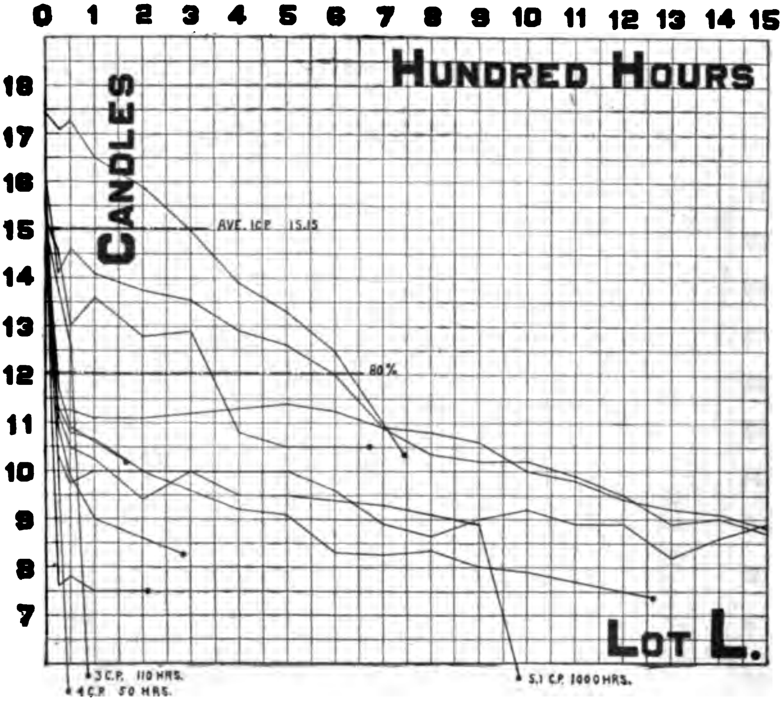


FIG. 27—LIFE CURVES OF LOT L

new average figure caused by the burnout and from thence assume the trend of the lot. To plot an absolutely accurate average curve would require almost innumerable readings. On account of the inaccuracies above stated, the candle-hour area of each lot was determined by tracing the individual curves of each lamp instead of tracing the average curve for the lot. This insures a very high degree of accuracy.

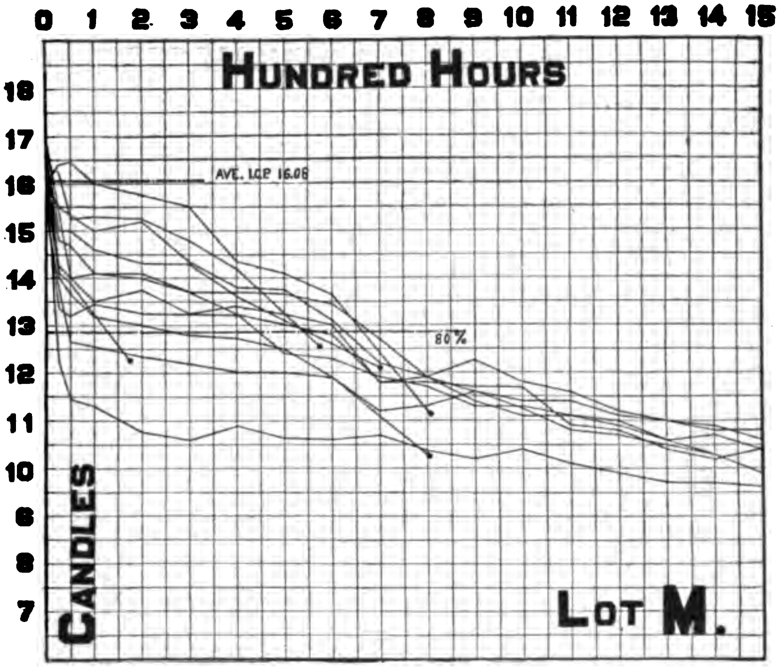


FIG. 28—LIFE CURVES OF LOT M

*Spherical-Candle-Power Tests*

Figure 33 shows the details of a rotating device for use in connection with the photometer for measuring the candle power at various angles. The lamp socket A is mounted on the end of a sleeve which projects from the end of the hollow shaft, adjustment for the different lengths of the various lamps being afforded by means of the clamp B. Wire connections are made from the lamp sockets through the

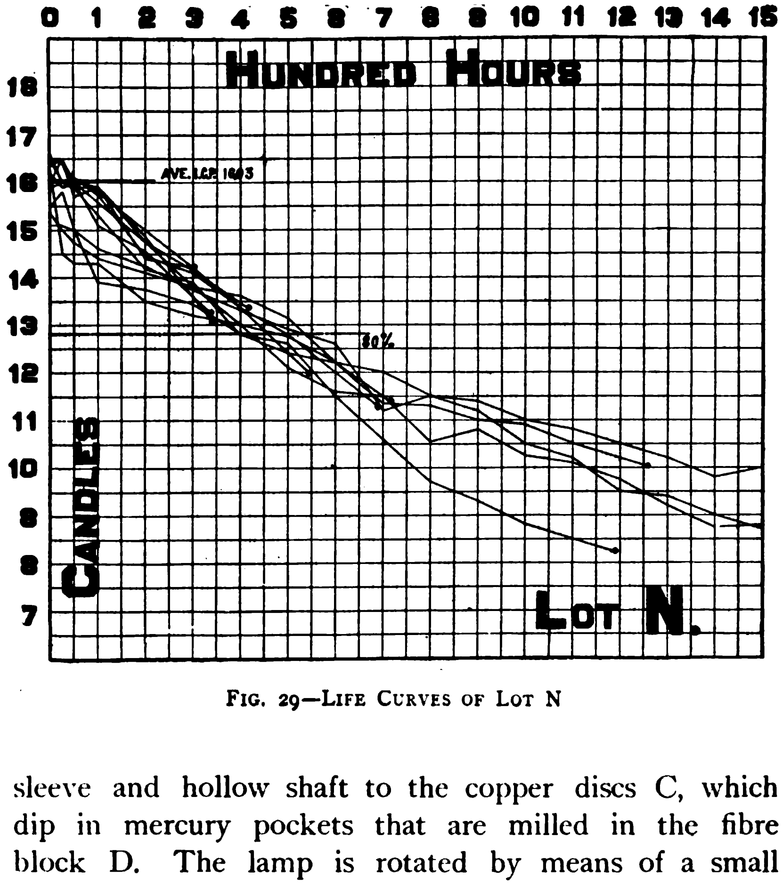


FIG. 29—LIFE CURVES OF LOT N

sleeve and hollow shaft to the copper discs C, which dip in mercury pockets that are milled in the fibre block D. The lamp is rotated by means of a small motor, which is belted to the large pulley on the loose sleeve E. A belt passing over the small pulley on loose sleeve E and under the idler pulleys, drives the hollow shaft in the main bearing by means of the small pulley bearing B. The pulleys are of fibre. Upon the base of the device is mounted the salce F, which is calibrated in degrees. A pointer attached to the hub immediately above the loose sleeve indicates on the scale the exact relation of the axis of

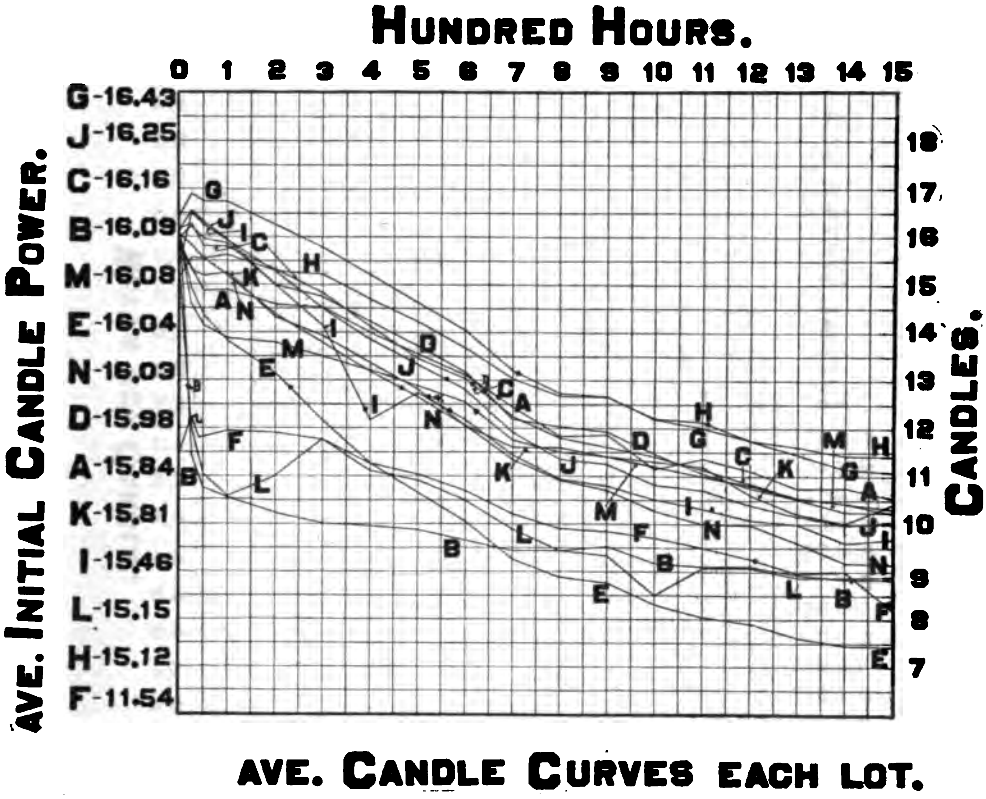


FIG. 30

lamp to the axis of the photometer, the lamp being maintained in that position by means of the set screw G which bears on the vertical shaft.

Six new lamps were selected at random for each of the various lots for the spherical-candle-power tests, and the data of this test represent the average results of the six lamps of each lot. To obtain the relation between the mean spherical and the mean horizontal candle power, the lamps were placed upon

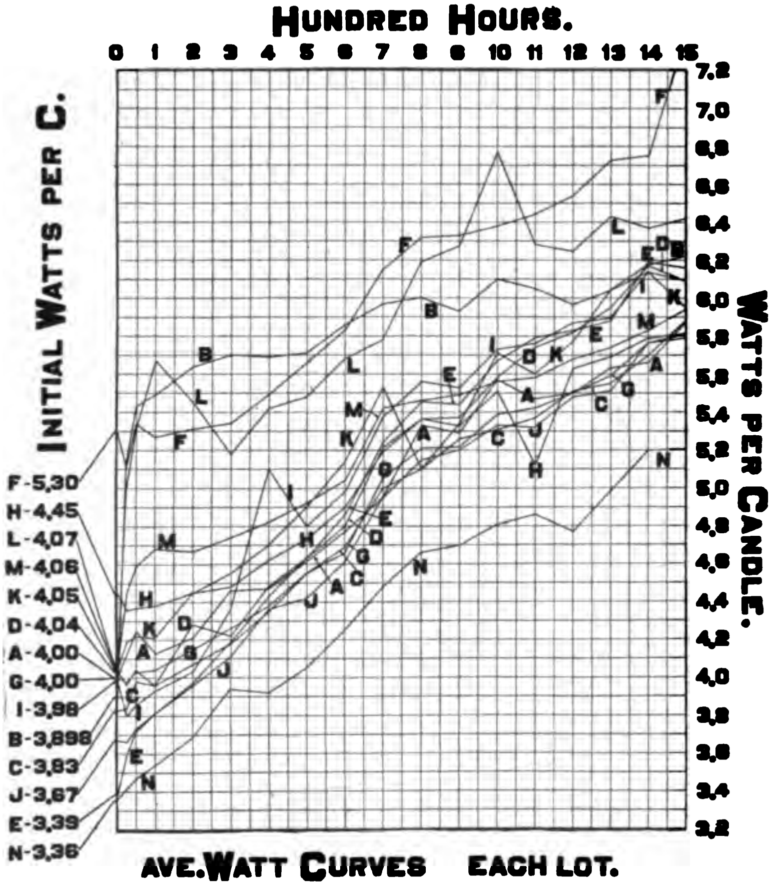


FIG. 31

a revolving stand and driven at 300 revolutions per minute. The mean horizontal candle power was obtained with the axis of rotation at right angles to the axis of the photometer, and this position is called

90 degrees as shown on spherical candle power diagrams, and position with the axis of rotation coincident with the axis of the photometer and with the base toward the photometer is called 0 degrees, and with the tip toward the photometer 180 degrees. Candle powers were determined with the axis of rotation in different relation to the axis of photometer as follows: 0, 5, 15, 25, 35, 45, 55, 65, 75, 85, 90, 95, 105, 115, 125, 135, 145, 155, 165, 175 and 180 degrees.

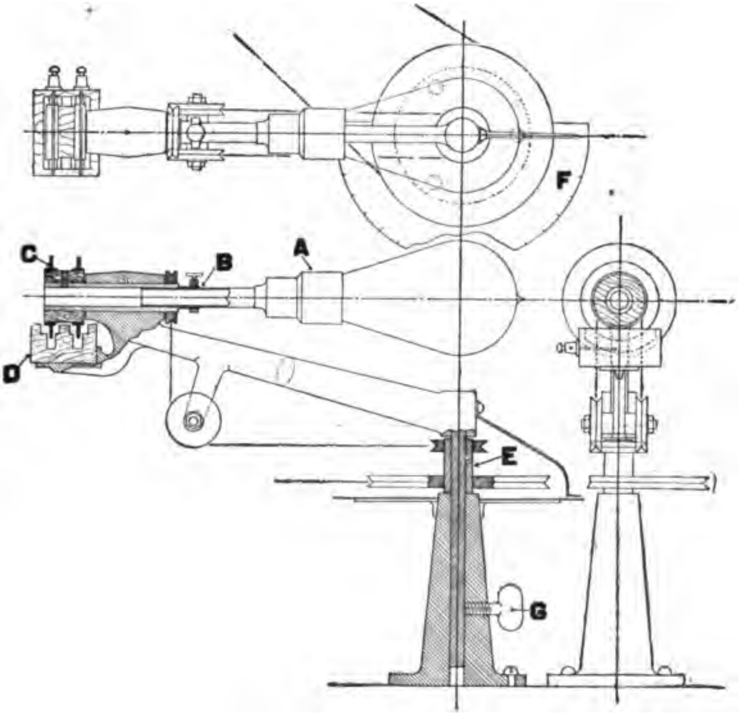


FIG. 33 ROTATING DEVICE FOR SPHERICAL CANDLE-POWER MEASUREMENT

These candle powers were converted into per cents of the mean horizontal candle power and a curve of these percentages was plotted for each lot of lamps

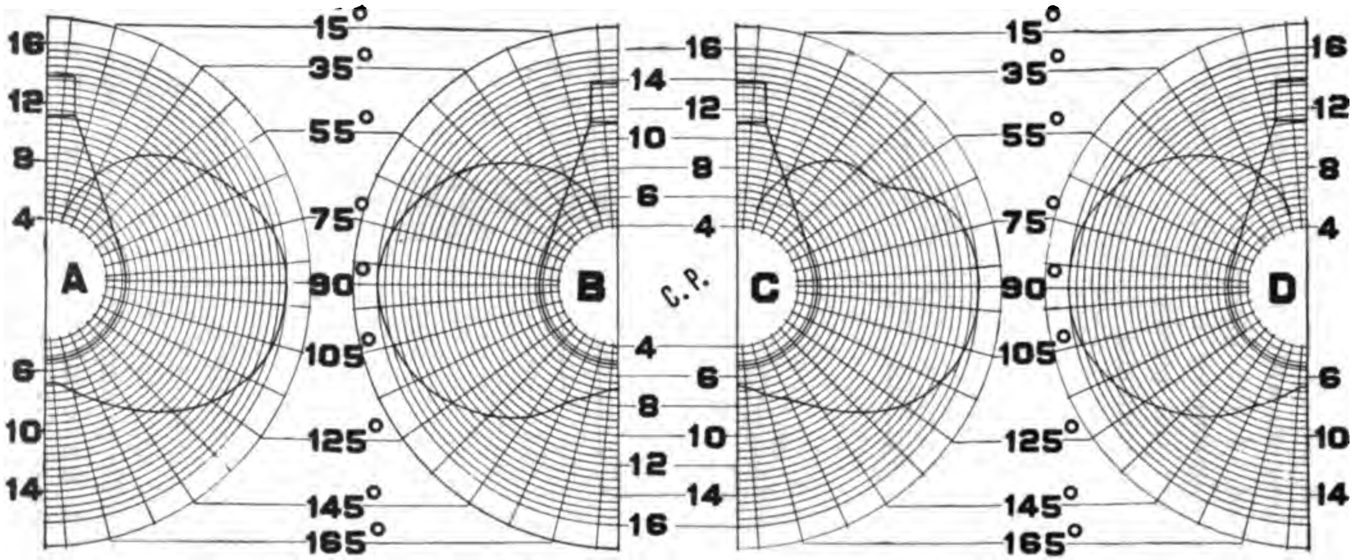


FIG. 34—SPHERICAL DIAGRAMS OF LOTS A, B, C AND D

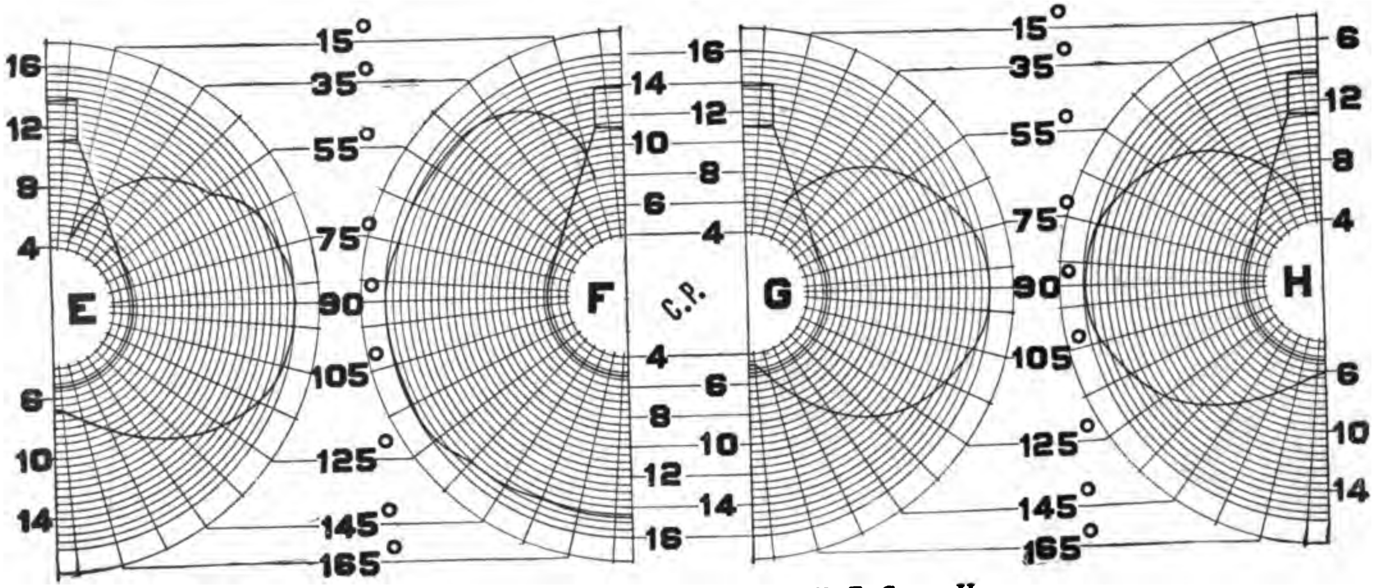


FIG. 35—SPHERICAL DIAGRAMS OF LOTS E, F, G AND H

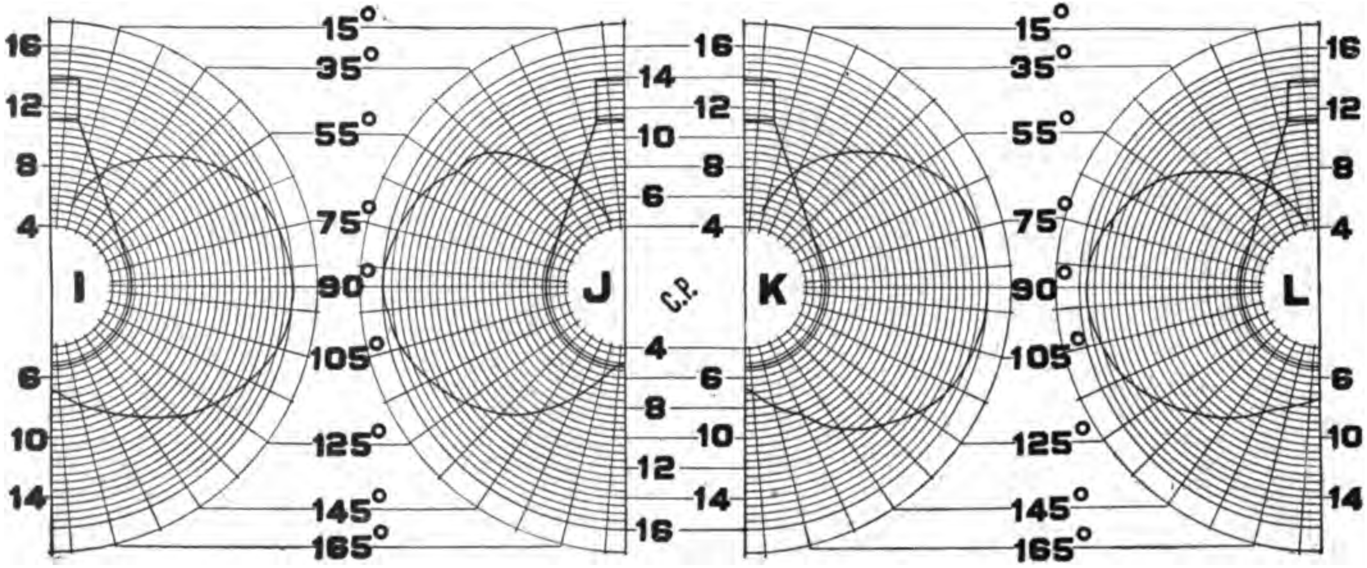


FIG. 36—SPHERICAL DIAGRAMS OF LOTS I, J, K AND L

tested. The area inclosed by curve divided by the area of the whole rectangle gives the net percentage that the mean spherical candle power is of the mean horizontal candle power. The diagram was made by constructing a rectangle whose height is the mean horizontal candle power and whose length is twice the height, and erecting perpendiculars at distances from the middle of the base equal to the height multiplied by the cosine of the angles that the axis of the rotation made with the axis of the photometer.

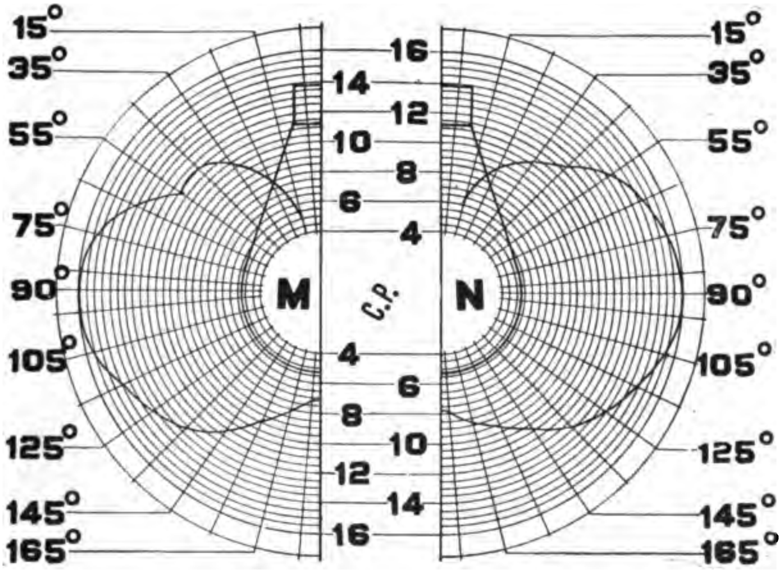


Fig. 37—Spherical Diagrams of Lots M and N

All the candle-power measurements throughout the tests are based upon the mean horizontal candle power, and the relation between the mean spherical and the mean horizontal candle power is shown in the list of percentages in column 3 of the table shown in Figure 38. Applying the factors showing the relation between the

| Lot | Type of Filament | Relation of Mean Spherical to Mean Horizontal c.p. in per cents | M. H. C. P. / M. S. C. P. |
|---|---|---|---|
| A | Double oval................ | 81.88 | 1.221 |
| B | " " ............... | 82.46 | 1.212 |
| C | " " .. ............. | 82.13 | 1.219 |
| D | " " ................. | 82.88 | 1.206 |
| E | " " ................. | 81.50 | 1.227 |
| F | 3-coil elip. spiral............ | 96.08 | 1.0408 |
| G | 2 loops in series............. | 80.32 | 1.245 |
| H | Double oval...... ...... ... | 82.10 | 1.218 |
| I | " " ................. | 82.69 | 1.209 |
| J | " " .. ... ......... | 80.94 | 1.235 |
| K | " " ................ | 84.81 | 1.179 |
| L | " " ................. | 81.42 | 1.228 |
| M | 2 ovals in series.. ......... | 83.42 | 1.199 |
| N | 2-coil spiral in series......... | 84.23 | 1.187 |

FIG. 38—RESULTS OF SPHERICAL CANDLE-POWER TESTS

| Lot | Average Watts per Initial Mean Horizontal c.p. | Average Watts per Mean Horizontal c.p. During Useful Life | Average Watts per Initial Mean Spherical c.p. | Average Watts per Mean Spherical c.p. During Useful Life | Average Watts per Mean Horizontal c.p. During Test of 1,500 Hours | Average Watts per Mean Spherical c.p. During Test of 1,500 Hours |
|---|---|---|---|---|---|---|
| A | 4. | 4.40 | 4.88 | 5.37 | 4.99 | 6.09 |
| B | 3.89 | 4.5 | 4.73 | 5.45 | 5.77 | 6.99 |
| C | 3.83 | 4.23 | 4.66 | 5.15 | 4.89 | 5.94 |
| D | 4.04 | 4.34 | 4.87 | 5.23 | 5.10 | 6.15 |
| E | 3.39 | 3.76 | 4.16 | 4.61 | 5.06 | 6.21 |
| F | 5.3 | 5.88 | 5.52 | 6.12 | 6.08 | 6.33 |
| G | 4. | 4.39 | 4.98 | 5.47 | 5. | 6.23 |
| H | 4.45 | 4.89 | 5.42 | 5.95 | 5.09 | 6.2 |
| I | 3.98 | 4.10 | 4.81 | 4.96 | 5.20 | 6.28 |
| J | 3.67 | 4.10 | 4.53 | 5.06 | 4.83 | 5.96 |
| K | 4.05 | 4.88 | 4.77 | 5.28 | 5.20 | 6.13 |
| L | 4.07 | 4.5 | 5.00 | 5.42 | 5.85 | 7.18 |
| M | 4.06 | 4.73 | 4.87 | 5.67 | 5.23 | 6.27 |
| N | 3.36 | 3.73 | 3.99 | 4.38 | 4.38 | 5.1 |

FIG. 39—EFFICIENCY TABLE FOR HORIZONTAL AND SPHERICAL CANDLE POWER

M. H. C. P. and the M. S. C. P., to the average initial watts per candle of each lot of lamps on the life test, gives the watts per mean spherical candle for each lot of lamps, as shown in table in Figure 39. The efficiency measurements throughout the tests are based upon the mean horizontal candle power and the total watts. The variations in candle power between the stated angles for the various lots of lamps under test is shown by the spherical candle-power curves Figure 34 to Figure 37 inclusive.

About three-fourths of the makers use the double-oval shape of filament, and while the spherical candle power diagrams show some differences in the distribution of light, the relation of the mean spherical to the horizontal candle power in the various lamps fitted with the double-oval filament, shows comparatively little difference.

### *Useful-Life Results*

The curves showing the change of volts, watts per candle and life due to different candle powers, which were presented to you by Mr. Willcox, have been proven to be correct by experiments made by the engineer of a western lamp manufacturer, and these curves were used in reducing some of the results to a common basis.

Selecting lot N, the highest-efficiency lamp under test, as a basis, the above-mentioned curves were used to reduce the various lots to a common basis. The results were figured by arithmetical proportion and show the point at which the average candle-power curve of each lot should have crossed the 80-per-cent limit line, allowing for the different efficiencies at which the various lots operated. The results in column 3 in the following table are based on the relative average initial watts per horizontal candle power. The results in column four are based upon the average watts per initial mean spherical candle power. This last column reduces all lamps to a common base of efficiency and spherical candle power. Results in column five are candle-hour areas reduced to a common base of initial spherical watts per candle.

| Lot | Life in Hours at which Average c.p. of Lot Declined to 80% of Initial c.p. | Period of Useful Life Reduced to Basis of Equal Initial Horizontal Efficiency | Period of Useful Life Reduced to Basis of Equal Initial Mean Spherical Efficiency | Useful Candle-Hour Areas Reduced to Equal Basis of Initial Spherical Efficiency |
|---|---|---|---|---|
| A | 635 | 285 | 267 | 3,747 |
| B | 20 | 10 | 9.5 | 332 |
| C | 620 | 345 | 312 | 4,463 |
| D | 638 | 273 | 267 | 3,780 |
| E | 234 | 225 | 195 | 2,854 |
| F | 1,210 | 156 | 278 | 2,483 |
| G | 708 | 318 | 259 | 4,029 |
| H | 1,109 | 315 | 279 | 3,104 |
| I | 567 | 260 | 252 | 2,972 |
| J | 562 | 364 | 323 | 4,530 |
| K | 525 | 222 | 241 | 2,196 |
| L | 47 | 19 | 17 | 506 |
| M | 620 | 254 | 259 | 2,725 |
| N | 467 | 467 | 467 | 6,545 |

FIG. 40—TABLE OF ACTUAL AND ESTIMATED USEFUL LIFE

## DISCUSSION

THE PRESIDENT: Is there any discussion on this paper?

MR. WILLCOX: I want to thank Mr. Bailey for this paper, which shows a great deal of careful, painstaking work. It is the first complete report we have had of the performance of the various types of 220-volt lamps, and is of great importance on account of the increasing use of these lamps to-day. In the first place, it should be noticed here that we have a lamp that starts with an initial efficiency, horizontal measurement, of 3.36 watts per candle, or 3.4, and gives a useful life of 467 hours. This is as good as the useful life of a 100-volt, 3.1-watt lamp. We have these two lamps, then, on an equal basis, with a difference of only .3 watts per candle in efficiency. This gives us a definite comparison of the 100-volt and the 200-volt lamp. The limits of candle power and watts mentioned by Mr. Bailey are too narrow for the 200-volt lamps. We can not prescribe the same limits for 200-volt lamps as for 100-volt lamps, because of the very much less demand for the 200-volt lamp. The manufacturer must therefore have a wider range.

I would call attention to the method employed for correcting the results so as to bring the two lamps to an equal comparative basis. Your committee has pointed out that the spherical candle power is the only proper basis for comparing lamps. In this case, the lamps are first tested on the horizontal candle-power basis and the results obtained afterward corrected. For example, Lamp *A*, on page 396, has an efficiency of four watts per candle initial horizontal, and so on throughout the tables. Spherical candle-power measurements give the spherical factors for each make shown in last column of table 38, page 396. We see here that the factor for Lamp *A* is 1.221, so if we multiply the horizontal watts per candle by the spherical factor, we get the mean spherical watts per candle, which are 4.88, shown in column 3, figure 39. Thus, having obtained the spherical efficiencies for the different makes, we proceed to reduce them to a common basis of efficiency by using the curves given in the paper presented at last year's convention, on "The Practical Side of the Incandescent Lamp." In this way we correct for the differences in shape of filament and differences in initial efficiency and bring all the lamps to an equal comparative basis. The mean spherical candle power is commonly obtained by measuring lamps in different positions. It is not necessary to do this, however, as it is practicable to obtain the corrected average spherical candle power by measuring, first, the horizontal candle power of the lamp, and, second, the tip-end candle power. Then by taking .7 of the horizontal plus .3 of the end, we have the mean spherical candle power.

THE PRESIDENT: We have had our time taken up somewhat by matters extraneous to the programme, and for that reason it is probable that we shall not be able to carry out in all its detail the programme that we have mapped out for the convention. It will probably, therefore, be well to take a vote to ascertain which topics that appear on the programme are of most interest to the members.

A vote was then taken, with the following result:

| | |
|---|---|
| Rates, | 27 |
| Hot Water *versus* Steam Heating, | 13 |
| Free Lamp Renewals, | 5 |
| Improvements in Meters, | 5 |
| Advantages of Gas Engines, | 3 |

# RATES

(Vice-President Hunt in the chair.)

MR. DOHERTY: Mr. Chairman and gentlemen: I think there are about four important points in making rates. The most important point is, what system of rating will bring in the largest profit on a given investment, and the same uniform rate to the consumer; or, I might say, the same average rate, because by none of these systems that are now advocated does the consumer pay on either the basis of his capacity entirely, or the basis of his consumption: the rate is composed of both these factors, and therefore his rate may be anything per kw-hour, or per lamp installed, or per lamp demanded. The other points are largely matters that, either directly or indirectly, have a bearing on the legality of any system of rates. It is generally understood that a quasi-public corporation must treat all consumers alike. Now, we find some very marked examples of departure from that plan. This is especially to be noted in the case of railroad companies, who charge the highest rate of freight for the class of freight that can be handled cheapest—live passengers, who can load and unload themselves. Such a system of rating is based entirely upon the theory that it is legal, equitable and desirable to base their rates on what the traffic will stand. I doubt whether some of the systems of electric rates now in use would be considered legal by certain courts. I think it would depend entirely—almost entirely—upon how intelligently the system of rates were defended; if it were defended with sufficient intelligence and sufficient industry, almost any system could be made to appear legal. Of course it is of prime importance that we should not adopt a system of rating that the courts of the country would afterward decide that we must abandon because of its illegality.

The system of rates that I advocate was not evolved from any desire to formulate a system of rates, but was evolved by the conditions that I was compelled to meet. I am connected with several central stations. The conditions under which we operate are different in each station. I felt that any system of rates that was adopted should be universally applicable to all of these stations. They are stations operating by water-power, by steam, and by gas engines; and they are scattered from Quebec and St. Paul on the north to San Antonio, Texas, on the south, and from Long Branch on the eastern coast to Denver in the West. We struck so many different conditions that there was no system of rates universally applicable to all of these central stations, nor was there a system of rates that I felt was applicable to even any single one of them. I therefore tried to make an analysis of the expenses that go to make up the amount we should be compelled to charge each consumer. I found there were several factors that influenced our expenses, and that these expenses did not necessarily bear any exact relation to each other. The first one that I may mention was the distance from the station: the farther you have to transmit the current, the greater will be the investment and the greater will be the loss; and yet that loss in an alternating-current station is almost insignificant when compared with certain other losses. I do not believe you can distinguish between consumers on the basis of distance from the station, because they say, "Why don't you locate your station in our neighborhood;" and if you are going to distinguish between consumers that live at different distances from the centre of the town (I think you should take the centre of the town in locating your station, but we start in with the assumption that the station is already located and that the poles and wires are up), you will find that the loss in transmitting current to any point in the city is very insignificant when compared with other losses that you are compelled to meet.

The system of rates that I advocate is based on, first, the expenses due to taking care of the consumers' accounts, and other similar expenses; second, the expenses occasioned by the capacity that the consumer demands, and, third, the expenses occasioned by the amount of current consumed. The charges might be outlined as (1) the consumer or meter charge; (2) capacity charge, and (3) current charge. Now, I will not go into every item of expense that goes to make up these charges; but I will say that it costs no more to read a meter when a man uses a great deal of current than when he uses no current. It costs the same to read a meter whether it be a 10-ampere meter or a 20-ampere meter. It costs the same to make out a bill for each consumer, no matter how large or how small his consumption may be. Your office rent, your executive salaries, and a great many other items, might be considered as just about in proportion to the number of consumers, and ought to be divided on that basis. Also, no matter how small a consumer may be, you must have a pole line on which to carry your conductors to him, so he should stand a part of the interest and depreciation charges and a portion of the pole-line investment. As to the capacity charge, you have certain other expenses proportional to your capacity. It makes no difference how many consumers you have, how much or how little current is sold, there are certain expenses that are just the same, dependent entirely upon the capacity you must be in position to furnish. That can best be illustrated by going back for a moment to the consumer charge. You have a certain shunt loss, which goes on all day long. You can not compensate for that by speeding up the meter, because you would have to know how long the meter was going to run. If you ran it one hour a day at full load, you could calibrate it fast enough to record shunt loss for 24 hours, but if you ran it two hours a day, you would charge twice as much as your shunt loss; if you ran it only half an hour a day, you would charge only half as much. It is a fixed expense, and there must be a fixed charge to cover it equitably. The capacity charge can best be illustrated by the core losses of the transformers. You must remember that the core losses in the transformer are not greatly different from an interest charge. These losses go on constantly—365 days in the year and 24 hours every day—regardless of how much current a consumer uses. There is a difference, but it is so small that it is not worth considering. If I were using individual transformers, I should in that case be furnishing 100-per-cent transformer capacity. If my core losses were two per cent of the capacity of these transformers, my loss would amount to 9 or 10 kw-hours per lamp per year, if I used 3.5-watt lamps. You have in a city lamps that burn from one kw-hour per lamp per year to 400 kw-hours per lamp per year. You can not take care of that fixed expense of your transformer by adding it to your kw-hour rate. Neither can you take care of it by adding it to any capacity rate based on kw-hour consumption. That is a fixed expense, and the only way in which you can cover it so that each consumer pays just that portion of it that he occasions, is to make a fixed charge; then you can cover it exactly. Core loss is only one of the fixed charges; interest is another. Assuming that I have a consumer who uses one kw-hour per lamp per year,—and I have a great many such consumers in different cities in which the companies that I am interested in are located—now, if I am selling current at 10 cents per kw-hour I sell him one unit for 10 cents, but my core loss has been 10 units. So, in sending out one unit to be sold, I have sent out 10 units to energize the transformer, and my station output has therefore been 11 kw-hours, for which I have received 10 cents; so my receipts will be .98 cent per kw-hour sent from the station. If that man had used 10 units my send-out would have been 20 kw-hours and my receipts would have been $1.00, or 10 cents per unit sold, or five cents per unit sent out. When you get to 400 kw-hours per lamp per year—which is almost equivalent to constant operation of lamps 24 hours a day—this 10-kw core loss referred to is an insignificant percentage of the total amount of current sent out from the station. In this case I have sent out 400 units to be sold and I have sent out 10 units to be lost; so my total send-out is 410 units, and I have been paid for 400 kw-hours.

Assuming that you eliminate all these fixed expenses from your charges, that you take care of all your fixed expenses by making a fixed charge against them, why, then it costs just about the same per kw-hour to supply a consumer with current whether he be a large user, a small user, a long-hour user, or a short-hour user; and, no matter what kind of a user he may be, your expenses for the current are about the same per kw-hour. That kw-hour charge includes only boiler fuel, boiler-room labor and a proper proportion of engine-room labor that is caused by, and is proportional to, the amount of current sent out; and then it takes in a certain proportion of the other expenses influenced by the amount of current you sell, to the extent that they are influenced, and of course must take in free lamp renewals. When Mr. Willcox spoke yesterday about covering the lamp-renewal charge in fixed charges, I think he made a serious mistake, because your lamp-renewal expenses will be proportional to the amount of current used in the lamp, and therefore a fixed charge will not equitably cover them; neither will any kw-hour charge equitably cover a fixed expense.

I will say that we have adopted the system that I advocate, to a limited extent, in several cities. We are so well satisfied with it that we do not care whether anyone else uses it or not. We are going to use it, and expect eventually to sell all our current on that basis; but, as I said in opening these remarks, it is very hard to raise the price on any consumer. We find that if we were to enforce a charge computed on that basis, we might make some people pay a dollar or two per kw-hour for current. Their use of the current is so little that the fixed charge would have so few kw-hours to be divided into it that it would bring the cost per unit to a very high figure. We have therefore adopted in several cities what we term an optional-rate scheme; if any of our present consumers would be benefited by it, we allow them to avail themselves of it. In other words, instead of making reductions in the usual way (and I think we all agree that we can gradually reduce prices from time to time, and that it is wise to make these reductions when we can), keep your fixed rate for sales of current by old method the same, and introduce this system of charging, reducing the original amounts fixed upon from time to time as conditions will warrant. In Madison, Wis., we charge $12 per consumer per year, plus $1.80 per lamp demanded, plus the rate of six cents per kw-hour for current; giving a discount of 10 per cent from the entire charge. This is the rate that prevails in most of the cities in which we are interested. In Denver, we have a fight on hand and have competition there, and a year ago we attempted to fix our rates where no one could make money. You understand that these rates are capable of mathematical computation which will tell just what is equitable and just what is right, but if you can not enforce these rates on the consumers who would not be favorably affected by them, you must start in with an arbitrary rate higher than the rate you figure, and then as you eliminate these consumers you have to work toward ideal conditions; in other words, it must be a process of evolution, and not a process of revolution. In Denver, we fixed our rates at $12 per consumer per year, plus $1.80 per lamp connected (it is unfair to charge connected lamps; the rate should be made on demand lamps, but at the time we inaugurated the rate we could not find any satisfactory limiting device, but we shall correct this error as soon as circumstances will permit). We then charged five cents per kw-hour for current. From that we gave a discount of 50 per cent and 10 per cent. This made the consumer charge $5.40, the lamp charge 81 cents, and the current charge 2.25 cents per kw-hour, including free lamp renewals. I will tell you something about the effect this system has had on our business in the cities where we have inaugurated it. A great many consumers whose bills would be reduced by the adoption of this rate have simply taken the reduction; they have not increased their consumption at all. Others have used slightly more current—20 per cent to 50 per cent in some cases—due to the natural increase of their business and not due to getting the lower rate or getting a rate on a different basis; while others have increased perhaps the same amount, due entirely to a reduction or to the method of charging. Then, there are certain other customers who have made a very material increase in their consumption, due entirely to the form of rate. For instance, one man I have in mind just now has increased his consumption something like 400 per cent since this rate was given him. There are other consumers that have raised their consumption by fully 1,000 per cent; that is, they are using ten times as much current as formerly. Now, when you require a man to pay a certain fixed charge, regardless of how much current he uses, and make him a low charge per kw-hour, the incentive to save in his light is not so great, because he can not save proportionally by saving on his consumption, and the incentive to use more light is stronger than it would be with a straight kw-hour method of charging, because he does not increase his bill proportionally by using more light. Now, without any material change in the cost to consumers for the same amount of current, the adoption of this scheme in Madison, Wis., with the ordinary growth of the town, which we thought would compensate only for a small amount of it, has resulted in an increase of 40 per cent in consumption; about 33 per cent to 35 per cent being due to getting a lower rate and to the method of charging. We know in a great many cases that our large increases have come from the method of charging. Some other method might have done it, but it would have required some method of charging where the increased consumption would not have added proportionally to the bill or the customer could not have saved proportionally by diminishing the consumption. We inaugurated that system of rates in Denver last April. I meant to bring you a statement of just how it affected our business. It was hardly noticeable for the first month or two, and then it began to grow very rapidly. In March, we sold 76 per cent more current than we did in the March previous; in April, it was 93.5 per cent. I promised my board of directors that I would increase 100 per cent during the year, and I have fallen shy 6.5 per cent.

I have nothing to say against the system advocated by Mr. Wallis. It approaches my own very closely, although he is trying to harmonize the difference between his true expenses and his former rate by letting the short-hour consumer off a little easier than would be warranted by his expenses, and in making the profitable consumer pay a little more. He has gone a step in the right direction; not a full step, but he has nearly taken it. Take the man who is burning light under the Kapp system of a two-rate meter, set so that he pays one rate between five o'clock in the evening and eleven o'clock at night and pays another rate for the remainder of the day. We will assume that his base rate is 20 cents. He uses one hour at night at 20 cents per kw-hour and one hour in the daytime at five cents. He pays 25 cents for two hours' use, or he pays 12.5 cents per kw-hour. Now, here comes another consumer, Number Two, who uses the current two hours at night and pays 20 cents a kw-hour, making 40 cents for the night use, and he uses one hour in the daytime at five cents, and his total charge is 45 cents for three kw-hours and his average rate is 15 cents. Is there any gentleman in the room who will not agree with me that he is the more desirable consumer? He is the more profitable consumer at a uniform rate to a station; and yet Number Two pays more than Number One.

A few words in regard to Mr. Ferguson's system, as he applies it in this country. I think Mr. Ferguson has taken a great step in eliminating the difference between winter and summer consumers. His expenses do not stop in the summer time, and there is no reason why the fixed charge should stop. But you can not make an equitable fixed charge on consumption per kw-hour, and that is what is attempted by the systems outside of Mr. Wallis' and my own. The first objection I have to the Wright demand system is this: Your expense curve will go something like this (indicating on the blackboard). With my system my cost curve can lie over that line (indicating). That line can represent my expense curve and it can represent my charge curve, or my charge curve can be represented by another line that would run exactly a uniform distance away from that. The Wright demand system comes in here, we will say, and comes across here (indicating) for two hours or one hour, as the case may be. Now, the man who uses his lights two hours is not benefited any more than the man who uses his lights one hour, and yet there is no question whatever but that the two-hour man is a much more desirable consumer than the one-hour man; and the half-hour man and the quarter-hour man are all on the same basis; they are all the same, and yet they are the consumers between whom you should distinguish the most. They are the consumers who give the big peak to the load, generally, and cause these large fixed expenses, and you must pay these fixed expenses by charging the profitable long-hour consumer more than he really ought to be compelled to pay. Now, their curve comes something like this, and then departs from that, because these are the consumers that have to pay for the loss caused by the other consumers.

We will take the consumer that uses his lights the year round and pays on the basis of his maximum monthly demand. In the first place, we are not interested in knowing what a man's demand has been, we want to know what it is going to be; that is what we provide machinery for. We want to know as nearly as we can what his maximum demand is going to be. We have one man in Denver with an elegant home, who insists upon having an individual transformer in his house and his primary wires laid under ground. He said he would not sign a contract based on the new system of rates, because he considered it was unfair. He wrote us that he had 600 lights in his ball-room, which he desired to use once or twice a year—when he gave a reception about Christmas time—and he contended that it was unfair that he should be asked to pay for that installation all the year round. But when we suggested that we should take out his transformer and put him on some kind of special rating, he objected to it, and said that every once in a while he had occasion to show someone the ball-room and he needed the lights on those occasions. Yet there is the transformer loss going on all the time. If you figure out the fixed expenses he occasions by lighting his ball-room two nights per year, and add to it his kw-hour rate, then if he used the lights three nights he would be paying too much, and if he used the lights only one night he would be paying too little. Now, say that if a consumer uses his lights a half hour 11 months in the year—I refer now to a jewelry store, taking an exact case in Denver—if he uses his lights half an hour a day for 11 months in the year and pays a rate of 20 cents, he pays $1.10 for 5.5 kw-hours; and then when Christmas time comes he uses his lights eight hours per night for 25 nights in the month of December, which amounts to 200 hours; for 60 hours of that time he pays the full rate and for 140 hours he pays the low rate. For 60 hours he pays 20 cents, which is $12, and for 140 hours the base rate is $7.00; and he pays a total of $20.10 per year. I am eliminating the minimum charge. Now, he has used a total of 205.5 hours—make it 205, for convenience—so he has paid a little less than 10 cents per kw-hour. Let us take another consumer who uses his lamps two hours each night in the year, or a total of 730 hours per year, and yet pays the full base rate of 20 cents, getting no discount at all; yet the first consumer uses his lamps on an average of but little more than a half hour per day and gets a rate much less than the second consumer, who is undoubtedly the more profitable of the two. If the Wright demand system in this country were applied on the consumer's maximum demand for the previous year — or, in other words, if his maximum demand should be the biggest year he ever had, and when he changes it you make a yearly contract with him and never allow him to diminish it except at the end of the year — if the Wright demand system were on that basis it would be more equitable, except that short-hour consumers are not paying the expenses that they occasion; and that means that you have to take the expense occasioned by these consumers and make the poor fellow who uses his lamps longer hours pay all the costs he occasions, pay all the profits you ought to have from him, and in addition pay all the additional expense that the short-hour consumer occasions and does not pay for, and make him pay, I suppose, a certain profit on them as well. My idea is that every consumer ought to pay at least the cost he occasions. I will guarantee that there is no system of rating thus far devised that will enable you to make every consumer pay all the costs he occasions, except the system that I have advocated. I am not trying to invent systems of charging; I simply want one—something that I can use in the stations in which I am interested. If anyone can show me a better system than I have adopted, I want to use it.

After having had two years' experience with this system, I am fully satisfied with it. The objections brought up against the system at the Chicago convention have failed to materialize. I find that the bills of consumers are fairly uniform throughout the year, and not unreasonable at any time of the year. There will probably be a kick this summer on the minimum charge. There was none last summer, because we had no people on it but were benefited throughout the year by paying the fixed charge, but during this past year hundreds of consumers have signed this rate who will not be benefited at all. I do not know why they signed, but they have done so; there have been too many of them for us to explain the system to them fully, and I anticipate that we shall have some complaints this summer. We had had three complaints up to the time when I left for this meeting. We are keeping pretty close tab on them, and, as I say, we have already had three complaints out of 7,300 consumers. I look for about 200 complaints to be received this summer, and that will be about one-ninth of the number of people who were on the rate who were not originally benefited by it. But there was a large number of consumers not originally benefited by the rate who came in and signed on this system, and they have now so increased their consumption that they are paying less than 10 cents per kw-hour. One consumer used to pay us about four or five dollars per month, paying us 16.2 cents per kw-hour. He came to the office to ascertain about this system of charging, and I called his attention to the fact that he would not save anything under the new rate. He asked if he could not buy additional current at a lower rate, and being told that he could, he said that he did not want to feel under the necessity of having to turn off the button every time he left the room in order to economize in the use of light, but he wanted to have the house look as if some one lived in it. He paid us for a couple of months this winter $17 or $18, and his average rate was only 5.5 cents per kw-hour. Our connected load has not increased anything like 93 per cent, and as our demand has increased only 32 per cent, you see the effect of the special form of rate and the reduction have had a tendency to give us a better load curve and a greater consumption per ampere of peak.

CHAIRMAN HUNT: If it is the pleasure of the meeting, we will now take up Mr. Ferguson's paper.

MR. WILLIAMS: It seems to me that, in view of the lateness of the hour, we would better adjourn, and continue this discussion after luncheon.

(The meeting then adjourned.)

# EIGHTH SESSION

President Doherty called the meeting to order at five minutes after two.

THE PRESIDENT: Gentlemen, with your permission I will announce the committee on final resolutions: Mr. Field, Columbus, Ohio; Mr. Conover, Philadelphia, and Mr. Davis, Williamsport, Pa.

We will now take up question No. 44, while we are waiting for a number of the delegates to finish their luncheon; they had to be served at a second table, owing to a larger attendance at this meeting than the hotel could provide for promptly.

(For question No. 44, see Question Box.)

(Vice-President Hunt in the chair.)

CHAIRMAN HUNT: We will now continue the discussion on the subject of rates, and will hear from Mr. Ferguson.

MR. FERGUSON: Mr. Chairman and gentlemen: Before proceeding with my paper, I want to say a word or two in answer to Mr. Doherty. He said he was glad to see that we had changed our method from 45 hours in winter and 15 hours in summer. I made the original arrangement of 45 hours in the winter and 15 hours in the summer for one purpose only, and that was to meet the theoretical objections that might be raised in conventions, at the time of the introduction of this system, to the method we employed. I did not feel at the time that it was the best thing to do, but that it was fair to experiment with; and I knew that there would be theoretical objections raised unless I was able to show that we approached the theoretical percentage of 100 as closely as possible. Of course, in changing from 45 hours in winter and 15 hours in summer to 30 hours the year round, we depart from the theoretical object of having every customer pay the full share of the company's expenses.

My position in all this rate-making is that it is not always advisable to adhere to strictly theoretical ideas; sometimes we have to depart from theory in order to meet commercial practice. I do not know that I can do any better in this discussion than to read my paper as I have prepared it; I believe that will actually save our time, and, with your permission, I will do so.

Mr. Ferguson then read his paper, as follows:

*Mr. President and Gentlemen of the National Electric Light Association:*

There is no subject, probably, upon which the successful financial operation of a central lighting and power company depends so much as that of rate-making. Whatever advance has been made in this country in determining a proper tariff for the supply of electricity has been one of evolution, and we find that the more progressive companies have abandoned the old methods of selling electricity at a flat amount per month or on a basis of discount for quantity only, and have adopted some more equitable method of charging.

The necessity for the adoption of an equitable method of charging is becoming more and more apparent, because we hear on all sides the city authorities bringing forward the cry of discrimination, and sooner or later those companies that are not prepared to go before their city council or their state legislature and demonstrate conclusively that the system on which they charge for the supply of electricity is equitable, will be subject to unfair uniform kw-hour price regulation.

An equitable method of charging, which is based on the underlying principles of the cost of production, will not only withstand the attacks of the city and state authorities, but will return to the stockholders of the central-station company a fair dividend on their investment.

The advocates of a uniform kw-hour price advance the argument that electricity can and ought to be supplied on conditions similar to gas. It is very doubtful, however, if there is any other business carried on under conditions similar to those under which electricity must be supplied. The production and sale of electricity differ from any other business in that the supply company must manufacture its product only as it is required, and it can not be commercially stored, consequently the company's plant and mains must be governed by the maximum demand made upon them at any time. Further, the customers will not wait for the supply and can not be prevented from taking it whenever they desire.

If the municipality or state should prescribe that a uniform kw-hour rate should be charged to all consumers, the effect would be to prevent the extension of the advantages of electricity to all classes in any community, because the price, in order to be sufficiently high to make a fair return on the investment in central-station and distribution system, whether it be owned by private or municipal corporations, will necessarily be too high to allow the company to supply electricity to large establishments requiring large quantities of electricity or to small establishments requiring light for a large number of hours daily. Such a uniform kw-hour price requires the company to sell its product to some classes of customers at an absolute loss and prevents it from supplying its product to other consumers, from whom it might obtain a profit, at a price lower than the price required by the municipal or state law. This point is one that is universally lost sight of by legislators and by advocates of a uniform kw-hour price, and to prove it we need only turn to the oft-advocated gas analogy. The gas company, with its regulated and uniform price of $1.00 per thousand cubic feet, can not compete with electricity produced by private plants in large establishments; in fact, it is possible in large mercantile establishments and factories, where the light is required for 8 or 10 hours daily, to produce electricity in a private plant at much less than the cost of gas purchased at $1.00 per thousand cubic feet.

The central-station company manufacturing electricity and selling its product on an equitable basis, discriminating justly in its tariff between the profitable and unprofitable consumer, may extend the advantages of electricity to the entire community, selling its product at a high rate to the customer using the company's investment for a short period daily, and at a lower rate to the consumer using the company's investment for a long period daily. A central-station company operating under such a system of rates is able to obtain a reasonable and fair profit from all classes of customers and does not exact an excessive profit from one class of customers to make up for the loss incurred in supplying the unprofitable class.

The courts have determined, as to other lines of public service, that discrimination is lawful provided it is not unjust, and it certainly can be proven that any discrimination in the rates for the supplying of electricity which is based upon the cost of the supply of electricity to the customer is just; and it is my further belief that it can also be proven that the method of charging a uniform price per unit of electricity supplied, which bears no relation whatever to the cost of production, should be classed under the head of unjust discrimination, and therefore less fair and less reasonable than an equitable and variable tariff based upon the cost of production.

For the first five years of the operation of the Chicago central-station companies it was their practice to charge a uniform list rate per kw-hour, with varying discounts ranging up to 20 per cent, depending upon the quantity of electricity supplied. It was soon found necessary in many instances, in order to retain the business, to increase the discount. This was especially true in the cases of large consumers, and the writer, about nine years ago, in order to establish a more definite and satisfactory system of dealing with customers, devised a form of contract which embodied an agreement on the part of the customer to use the company's service to the exclusion of all other methods of artificial illumination for a period of from one to five years. The discount allowed from the list price in each of these contracts was fixed for the term of the contract and was determined by the character of the customer's load factor, which was estimated in advance. A minimum monthly or annual payment was guaranteed the company by the customer, the amount of the minimum in every case approaching as nearly as possible the anticipated net bills. The company, through this method of charging, made very rapid progress in interesting large consumers in the central-station service, and was remarkably successful in convincing owners of isolated plants of the advisability of abandoning their operation and adopting the company's central-station service.

It soon became evident, however, that in an extensive lighting and power business, such as is to be obtained in Chicago, the method we had been employing with the large consumers could not possibly be applied to all our customers, as the load factor of each could not be pre-determined with accuracy and a large corps of assistants would be required to handle the business of rate-making properly, so that it might be fair to all customers alike, and profitable in all cases to the company. We experimented with the system of charging based upon the number of hours' use of the connected load, and, as might be anticipated, this proved to be only a makeshift and had only limited success, since it was lacking in correct principles and bore no relation whatever to the cost of production. The minimum guarantee per lamp connected prevented the installation of lamps in places where they might be used only intermittently, and thus limited the advantages of the use of electricity, especially in the home.

Realizing the necessity of a general system of charging that would be commercially sound in principle, and not only equitable for all classes of customers, but also automatic in its action, we decided to employ that system which seemed to afford the best solution of the problem, of allowing a reduction in rates and at the same time providing a fair return to the company from all classes of consumers for the service rendered. Our success with the load factor and minimum guarantee system as employed with the large consumers, together with the full realization of the principles underlying the cost of supplying each customer, led us, in 1897, to adopt for all new business and for the gradual readjustment of our existing business the Wright demand system in a modified form.

The system as employed in Brighton, England, while admirably adapted to the customs of the English people and the conditions surrounding a municipal corporation, was considered unsuited to the commercial methods prevailing in this country, and it was decided that the system should be Americanized. To fill the requirements of American conditions the writer suggested the method of basing each monthly bill upon the customer's actual maximum in that month, and to charge the full rate of 20 cents per kw-hour during each of the six winter months for all electricity consumed monthly until the consumption reached the equivalent of 45 hours' use of the maximum number of lamps lighted simultaneously as indicated by the Wright demand meter, and to charge 10 cents per kw-hour for all electricity consumed in excess of that amount. During the six summer months, however, the full rate was charged for all consumption until it reached the equivalent of 15 hours' use of the maximum number of lamps lighted simultaneously, and for all electricity in excess of that amount the rate of charge was 10 cents per kw-hour.

The net rate obtained from this method, with the rates employed, would of course be too high for large consumers, and a wholesale discount was offered, the discount being taken only from the low-rate portion of the bill; the amount of this wholesale discount ranging from five per cent to customers whose low-rate portion was $100 and increasing by five per cent for each $100 of the low-rate portion, making the maximum discount 50 per cent in the case of a customer whose low-rate portion was $1,000.

We have within the last year simplified our method of charging by abandoning the difference between the summer and winter rates. We now charge the full rate of 20 cents per kw-hour for the equivalent of one hour's daily use of the maximum demand throughout the year, our reason for the change being that we found it objectionable to increase the rate of charge by the increase of hours in the fall months, just at the time when the consumer was beginning to use a larger quantity of electricity.

The method of charging for power business is as follows: The full rate is 10 cents per kw-hour for the first 30 hours' use of the maximum power per month.

Low rate:

Eight cents per kw-hour for the second 30 hours' use.
Six cents per kw-hour for the third 30 hours' use.
Four cents per kw-hour for the next 450 hours' use.
Three cents per kw-hour for the next 180 hours' use.

The low-rate portion of the bill is subject to the following discounts:

| | |
|---|---|
| From $ 20 to $ 40 | 15 per cent |
| From $ 40 to $ 60 | 25 per cent |
| From $ 60 to $ 80 | 30 per cent |
| From $ 80 to $100 | 35 per cent |
| From $100 to $200 | 40 per cent |

These rates for power give a range from 10 cents to 2.88 cents per kw-hour as a minimum.

Since the system was put into effect in 1897, we have kept very complete statistics showing the income at the different rates of discount. We have in use in Chicago at the present time a total of 13,022 Wright demand meters and 15,633 recording meters; the income from the customers using Wright demand meters being $986,560 for the fiscal year ending March 31, 1902. The average discount from the list is 35.1 per cent for light and 49.1 per cent for power. Of the Wright demand meters, 94 per cent are 25 amperes and under, showing that the bulk of our business on this system is with relatively small customers.

The total number of customers on our books is 18,623, of which 61.7 per cent are on the Wright demand system.

At the end of our fiscal year, March 31, 1902, we had 2,737 power customers, of which 50.7 per cent were on the Wright demand system.

The total investment in meters of all kinds on the company's system is $353,000, of which 23 per cent is for Wright demand meters.

The load factor for the Chicago companies for the last fiscal year was 27.1 per cent, showing an average daily use of the system's maximum of six and one-half hours.

The total yearly expense per recording meter in 1897, including the salaries of superintendent, bookkeeper, inspectors and helpers, miscellaneous supplies, repairs and renewals (before we adopted the Wright demand system of charging), was $2.95 per recording meter.

In the year 1901, the total yearly maintenance expense, including the same items, was only $1.85 per recording meter, showing that the cost of maintaining Wright demand meters is inconsequential.

Criticism has been sometimes made of the method used in Chicago, on the ground that the company might do a large amount of unprofitable business, owing to the fact that there was no guarantee to the company that the consumer would pay for at least one hour's daily use of the maximum demand. An analysis shows that of our total income from Wright demand business, only 8.6 per cent of the total comes from customers using the equivalent of their maximum demand for less than one hour daily, and further, that the ratio of gross bill to full-rate lamp-hours of these "shortage customers" is 57.3 per cent, so that the actual amount of business which falls short of using the maximum demand, one hour per day, is only 3.67 per cent, which I think may be considered small enough to be unworthy of criticism.

The ordinance under which we operate in Chicago provides that we shall not charge at a rate higher than one cent per 16-cp lamp-hour, so that we are prevented from exacting from our customers a guarantee that they will use the maximum demand at least one hour per day; but even though we were not prohibited by the ordinance it is very doubtful whether we should consider it wise to exact this guarantee from the customer, in view of the small percentage of shortage that actually exists in practice, for such exaction from the customers by the company is often the cause of bitter feeling and undesirable criticism, and sometimes results in unfair legislation which more than offsets the small gain in revenue exacted by the company under the minimum guarantee.

The full-rate portion of a customer's bill should, under no circumstances, be subject to discount, as in all equitable tariffs each customer should pay the cost to the company of preparing itself to supply the demand.

The cost of supplying electrical energy from a central power station may be separated into two clearly defined groups:

First—The cost of getting ready to supply and distribute energy.

Second—Cost of continuing the actual supply of energy.

These two groups may be designated as "*preparation*" and "*production*" costs, respectively.

In the manufacture and distribution of electricity from a central station, the preparation costs form by far the greater percentage of the total cost, and each customer must use the service of the company a sufficient length of time daily at the full rate of charge to insure the company against actual loss. After the customer has used the service of the company a sufficient length of time daily to insure the company against loss, then the company may sell the consumer the remainder of the electrical energy required by him at a fair margin above the production cost, to insure a reasonable profit on the investment. I believe, however, that the initial rate should be maintained as high as possible, and if it is found desirable to lower the charge covering preparation costs, it should be accomplished by reducing the length of time daily that the customer is required to use the maximum demand before obtaining the benefit of the low rate. This will lessen the amount of shortage from a certain class of customers.

The use of an indicator for determining the maximum demand, without limiting the same, eliminates all speculation and discussion as to the probable maximum demand of the customer, and puts the rate making in each individual case entirely in the customer's own hands, for the company installs the meter and the customer makes the rate by the manner in which he uses the service.

The value of a system of charging which places the rate making in the customer's hands, and eliminates all trading, as this does, must appeal strongly to one who has had much experience in making rates and negotiating contracts with a large variety of customers; and from five years' experience gained with this system, I am more strongly convinced of the necessity of some such equitable tariff being adopted by all the electric-lighting companies in every city and town, not only to serve justice to the customer, but also to protect the investor in illuminating properties from the loss of revenue resulting from injudicious contracting (so common, especially in the smaller cities and towns), and unfair municipal price regulation; both of which will become inevitable without a proper system of charging.

THE PRESIDENT: We will now listen to the other papers written for this discussion; those of Messrs. Wallis, Patterson, Scovil, Phillips and Dow.

The papers were then read, as follows:

### L. R. WALLIS

The inquiries that have come to the writer from all parts of the continent since the last meeting of the association, at which the paper upon the Foresee (4-C) System of Charging was presented,* establishes in his mind beyond a doubt that the central station managers of this country are fully alive to the necessity of the universal adoption of some uniform method of charging that will entirely succeed the "flat rate" and "uniform meter rate" charging.

It is somewhat interesting to note that, notwithstanding the rapid strides and radical departures that have been made in central station practice during the past decade, with but few exceptions the same methods of charging for the product of the central station are still employed. This would seem to substantiate the theory that either the commercial end has not kept pace with the engineering end, or that the original methods were correctly conceived and cannot be improved upon. Since they could not have originally been based upon cost, in the absence of cost data, it can hardly be claimed that they were based upon correct principles; consequently, attention to this important branch of the business has been universally neglected ever since the introduction of electric illumination. It is still the practice to make rates without sufficient analysis of cost, and especially without aiming to have each unit of energy sold bear its proper share of the fixed charges of the plant.

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* See Proceedings National Electric Light Association, 1901.

We cannot make much progress along the lines of equitable charging unless we do so with some carefully considered system. Considerable business now done at the highest rate is not profitable, and this indicates that some element other than the *amount* of energy used must be considered. Some have tried to regulate the time when the service shall be used, but it is not feasible to continue solely along these lines, as, in the very nature of the business, the power service seems bound to overlap the lighting service.

At the risk of repetition, I affirm that "capacity" is the central station's most valuable and "current" its least valuable property, or stock in trade. "Capacity" cannot be disregarded, depending upon the consumer to use enough "current" at the high price per unit usually charged under uniform meter rates to make a profitable return from each individual consumer. Minimum consumers should not receive their supply at less than cost upon the theory that there are enough good consumers to make up such losses as well as to return a profit on the whole operation. Strictly speaking, the customer that demands a certain capacity should not expect more, and should pay the fixed charges on that portion of the whole that is thus sold and, consequently, reserved for that particular customer. We should not, however, expect income from surplus capacity *in excess of that which is demanded to perfect the service.* The quantity of energy supplied can then be sold to all at a uniform rate per unit.

The amount charged for energy per unit should be just sufficient to pay the operating expenses and a proper interest on the investment, and should be always as low a rate as it is consistent to make. The charge per unit of consumption is *not essential,* except to equalize the charges; otherwise, we should find the same conditions that exist to-day, only less objectionable, because the amounts involved would be less; but capacity, or maximum power demanded by the customer, is the essential thing, and must be known in advance if the charge is to be equitable. Advance knowledge enables us to conduct business with better results. Whenever a customer pays the fixed charges on the demand he creates, it is then optional with such customer whether a profit is realized or not; but it is fair to assume that, having gone so far as to pay such an amount, energy will be used to make it profitable. Those that use the service most must pay the plant the most profit, which is as it should be. It makes all customers good customers, and does away with the complicated two-rate or discount methods.

Many water-power plants charge a flat rate per year per horse power, or per lamp used, and if this amount includes the fixed charges and an additional amount for expense and interest, it cannot be otherwise than profitable, and the rate need not be exorbitant.

Some plants are installed and all the power taken by one customer, in which case the profits can be accurately foretold for the year. If one customer in such a case, uses 1,000 horse power, and in the other, five hundred customers use 1,000 horse power, the difference in cost is for attendance outside the station operating, and additional investment. In the first case the load line may be assumed to be practically straight; but in the latter case a peak has developed, which has caused more dissatisfaction among station managers than all the other problems combined. If we sell the capacity represented by this peak, it need not cause dissatisfaction, even if it does exist. That the capacity charge will vary in different plants is but natural, but the result of such a plan must in the end be beneficial to both the customer and the supply company.

Since July 1, 1901, all the customers in the territory supplied by the company with which the writer is connected, comprising a population of thirty thousand people within ten miles of Boston, have been charged upon the Foresee (4-C) system, contracting with the company for a period of one year, agreeing to pay for the "capacity" demanded in sixteen-candle-power lamps, or their equivalent, at the tariff rates established (as per schedules contained in the report above referred to) plus "current" as shown by meter at six cents per kilowatt hour.

The legality of this method was questioned by certain consumers, and an appeal was taken to the State Board of Gas and Electric Light Commissioners.

who, after through investigation, rendered an opinion favorable to the plan. The following quotations are abstracted from their opinion: "Such a scheme of charging is, we believe, absolutely unique in the electric lighting business, and there is no experience by which to forecast its results reliably. It is evidently intended to *increase the profits of the company by increasing its output* and at the same time to reduce the price to a large majority of its customers, enabling them without proportionate increase in their bills to use lights much more freely and with increased convenience.

"It may be expected, also, in some cases of small consumption to increase the price per unit above that formerly in force (twenty cents per kilowatt), but only in cases where the ratio of hours burned to the number of lamps contracted for is very small. The operation of the automatic device for preventing the use of lamps above the contract number may prove at times inconvenient and offensive, but may also be an essential feature of the plan.

"The name of 'capacity charge,' and the way in which it was proposed to the public, seemed at first to indicate that it was intended to guarantee a definite, perhaps an increased, rate of dividend, but a careful scrutiny of the rates offered and the method by which they have been determined shows that they have been reduced below the amount that they theoretically would need to be in order to accomplish such guarantee.". . . . . "There is nothing, however, in its nature that removes it from the jurisdiction of the Board" . . . . . "The Board does not see its way clear at the present time to require further changes."

## RALPH J. PATTERSON

This question is becoming more and more important all the time, as the central stations realize that it is the only part of the business that has not been pretty well developed.

The system I found in operation here in Waterville was interesting, from one point of view, as being an indication of the natural tendency of all stations to base their rates upon capacity demanded. The schedule of rates was based upon the number of lamps contracted for, and the customer was allowed to make that any number chosen, except in some residences where ten lamps or less was the total number installed, in which case the actual number installed was taken.

The rate schedule was as follows:

FOR RESIDENCES

| No. 16-Candle-Power Lamps to Be Used Simultaneously | Price Per Month | Price Per Year |
|---|---|---|
| 1 | $0 80 | $ 9 60 |
| 2 | 0 95 | 11 40 |
| 3 | 1 10 | 13 20 |
| 4 | 1 25 | 15 00 |
| 5 | 1 41 | 16 90 |
| 6 | 1 65 | 19 47 |
| 7 | 1 87 | 22 47 |
| 8 | 2 08 | 24 96 |
| 9 | 2 28 | 27 36 |
| 10 | 2 46 | 29 50 |
| 11 | 2 63 | 31 57 |
| 12 | 2 78 | 33 36 |
| 13 | 2 92 | 35 10 |
| 14 | 3 05 | 36 54 |
| 15 | 3 13 | 37 50 |
| 16 | 3 27 | 39 20 |
| 17 | 3 35 | 40 12 |
| 18 | 3 42 | 41 04 |
| 19 | 3 47 | 41 67 |
| 20 | 3 52 | 42 20 |

All over, at 17½ cents each per month.

In operating under this plan, we find that people do not try to keep within the capacity contracted for, but use at times a number greatly in excess of that. It is the writer's belief that such a plan, with a suitable limiting device, can be operated successfully, as it must be patent to every one that, knowing the capacity required to furnish a customer, it is quite easy to calculate the amount of income necessary to realize the profits that must be obtained. Of course such a plan would be more beneficial to some customers than to others, but all have the same rights. In the case of water-power plants, such as this, this feature is not a very serious one to the company. In a steam plant it would perhaps be out of the question, but with certain regulations as to the use of the service, objections would be eliminated to a large extent.

For instance, we have one customer for 500 horse-power twenty-four hours a day at something less than $40 per horse power per year. Assuming another 500 horse-power to be delivered to five hundred customers with a demand of ten lamps each, or, say one horse-power, we could base our price on the continuous use of this service, if you like, and make the price accordingly; say $40 per year to each customer. The amount of power and the amount of income would be the same in each case, and if we add an amount to this charge to cover additional expenses incurred in serving more customers, we are apparently protected as well in one case as the other, and yet the price is not exorbitant. I should say that ten dollars per year additional would cover the extra expense of serving each of the five hundred customers. This would be about twenty dollars per year more than the schedule of rates submitted for ten-lamp demand, and forty-eight dollars more than twenty-lamp demand per year, but this schedule could be modified to meet the local conditions.

Any plan that cannot *foresee* the customer's demand is handicapped to such an extent that it is a question if it can ever be satisfactory.

## SAMUEL SCOVIL

The problem of devising a method of charging for current which shall be so uniform in its operation as will permit of its being applied to every customer without exception, and without any undue preference in any instance, is certainly one of the most difficult tasks, if not *the* most difficult, which the manager of a central station company supplying electricity is called upon to solve; and in many cases the problem is made more difficult by reason of certain restrictions being placed upon the company by the municipal authorities of the community which it is serving. A method of charging for current which will appear to meet practically all the necessities of the case in a community where the difference between the amount collected annually from the smallest and the largest consumers is comparatively slight, is found to be altogether inadequate where the difference between the annual amounts paid to the company by these two classes of customers is many times multiplied. A system which will meet all the necessities of the situation where the yearly amounts collected from individual customers average from $20.00 to $2,000, will not do so when the difference between amounts paid by individual customers is from $20.00 to $5,000 per annum; and with not a few companies this difference in amount paid annually, ranges from

$20.00 to $20,000, and even to two and a half times this latter sum in special cases. It takes 500 customers paying annually $20.00 each to equal one customer paying $10,000 per annum. The mere statement of this simple arithmetical calculation brings clearly to the minds of practical central-station officials the complexity of the problem they have to solve, to find a system which can be applied without deviation to the various classes of customers. If the load factor on the station is identical in the case of the 500 customers and the one customer, the difference in investment in a distribution system for the 500 and the one will vary considerably, and so will the cost of serving the 500 as against the one; and this difference in investment and cost of serving cannot be ignored if the $10,000 customer is to be offered a rate which will keep him from installing an isolated plant.

I confess that I do not see that in their application of the "ideal method of charge," recommended by Dr. Hopkinson, of England, so long ago as 1892, either Mr. Doherty or Mr. Wallis have arrived at a solution of the problem in the sense that I understand they mean to advocate as being essential, namely, that each and every customer shall pay the full and entire cost which he occasions the company serving him.

Mr. Wallis' "Forsee System" is sadly deficient in this respect, inasmuch as his plan of dividing the total installation and fixed costs by the capacity demanded, or to be demanded, fails to take into account this fact that there is a great difference in the cost of a distribution system for 500 customers and for one customer, and in the cost of serving 500 customers as compared with one customer. Hence, if he were obliged to figure with the one customer on the basis of a system for 500 customers, he could not make a rate that would get this business.

Mr. Doherty, through his charge "per customer," in addition to other charges, does provide for some of the difference which we know a company can profitably allow in serving the two classes of customers under consideration. He speaks of his experience in Denver with this method. To a man up a tree, this experience would seem to be of slight value. After adopting what he figures, I presume, to be an equitable (because only adequate to cover all costs and provide a fair profit) set of charges, he reduced these charges by a discount of 50 and 10 per cent, reaching thus, I infer, at once a point where with the great bulk of his customers the guarantees they are asked to make are so small that they do not have to give them any consideration whatever.

Almost any system of rates which will give a company's customers more current for the same money theretofore paid by them, or the same current for less money, always meets with their approval. All, therefore, I understand Mr. Doherty's system is doing in Denver is to allow him to carry on his competitive war on lines that tend to increase the load factor of his station, so that if there is any profit per unit in selling current at the price fixed by him, he gets all there is in the business.

So much in the way of criticism. Now, what can I suggest which will be in any way helpful towards meeting the conditions which Mr. Doherty well points out do need the combined attention of central-station men. if we would avoid serious inconvenience from having forced upon us by municipal authorities ill-advised and hurtful regulations. Only this. I assume that it will be conceded by all central-station managers who have studied the subject, that the cost of service to the consumer should be based in the main on the hour's use of the capacity demanded by him, and that the tariff schedule should be proportioned to the costs. These costs consist of those expenses which are fixed and those which are proportional to the kilowatt output. There is diversity of opinion between students of the subject as to what expenses are fixed and what are proportional to the output. Perhaps the appointment of a committee would result in an agreement upon these points. Until such an agreement is reached, certainly no universal system of tariff is possible. If such an agreement were reached, it would be found necessary probably to modify the tariff schedule from the cost simply of short-hour and long-hour users in order to meet commercial conditions. Further, as conditions are now, a central station must carry some connections at a direct loss. The sentiment of the communities served demands this at the present time, and a public-service company cannot afford to get much in advance of public sentiment in adopting new methods if these methods result in not a little inconvenience to many people. They must first be educated to the reasonableness of these methods, and education requires time and intelligent effort.

## E. F. PHILLIPS

The question of flat-rate lighting has never entered into the question of the conduct of the business of the company with which the writer is connected. Flat rates never seemed to us just or equitable, and, therefore, appeared to be an unwise business proposition, and we have, therefore, had no trouble from that source. I think the same idea was entertained by much the larger percentage of central-station managers from the inauguration of their plants, it only obtaining a foothold in the smaller cities and towns, and when forced upon others by competition.

Regarding the "uniform-meter rates" (which was the one first put in practice by us), it became evident several years ago that if we desired to extend our business to any considerable extent, or to popularize the use of electricity, some reductions would have to be made or other methods adopted.

The first to be tried was the reduction from 20 cents per kilowatt hour to 16 cents. This brought about quite a considerable increase in the output; and a small increase in the net revenue, yet it did not cause much of an influx of new business.

It was then decided to make a radical departure in the matter of rates, and a system was adopted whereby the consumer was required to pay at the rate of 16 cents per kilowatt hour for the first two hours per day, or 60 hours per month of his connected load; all current used in excess of this to be paid for at five cents per kilowatt hour, total bill to be subject to discount if paid within ten days from date of bill. This departure had the effect of widening out the curve of the peak load and brought quite a noticeable amount of new business. The net earnings per kilowatt hour of output fell off somewhat, yet the net earnings to the company for the year showed a healthy increase. During this time the regular rate for power service had been put at ten cents per kilowatt hour; this was changed to ten cents per kilowatt hour for the first 30 hours per month per kilowatt connected, excess current at five cents per kilowatt hour. Within a year the power rate was changed to ten cents per kilowatt for first 30 hours of "maximum demand" instead of "connected load." This brought about a very noticeable increase in power service and a corresponding change in the light-load curve. In the mean time, the two-hour per day rate had been applied to the residence service, and produced general satisfaction; the method pursued was an arbitrary one, and based on the average use, this to form the maximum demand at the 16-cent rate, with excess current at five cents, and minimum bill of $1.00 per month. The average earnings per kilowatt output in the residence district showed a decided drop, yet, notwithstanding this radical departure, the net earnings showed an increase, thus demonstrating that we were on the right track. This rate is the one still in use for residences.

The next move was the inauguration of the one-year contract on the "maximum-demand" plan, and the change to one hour per day at the sixteen cents per kilowatt price, excess current at five cents per kilowatt; the maximum-demand contract, however, to cover all electric service used by the customer. This has proved the most popular of any plan yet inaugurated, and is the one in general use by the company at the present time for all service except residences; but it is optional with the customer as to whether he shall take the open order at 60 hours per month of connected load or 30 hours per month on maximum demand. In the case of arc-lamp service, however, the customer is required to take the maximum-demand contract for one year. This maximum-demand arrangement necessitated the installation of the Wright demand meter in all cases where the connected load was known to be in excess of the demand. This form of contract also carries with it a minimum bill per month of sixteen cents per kilowat hour for the first 30 hours per month of the maximum demand. In the case of incandescent service or combination service, the customer is given the privilege of stating his estimated maximum demand, and a contract is written on that basis with provision that demand meter or meters shall be installed, and should the maximum demand, as indicated by the demand meter, exceed the estimated demand, the former shall be used as base for amount of current to be paid for at the high rate, and a consequent raising of his minimum rate, thereby making the fixed base automatic in its operation.

To show how our plan would compare with the "Foresee" system, I submit a few examples. In the case of a customer whose connected load was 120 sixteen-candle-power lamps, besides quite a number of show-case lamps, a demand meter was installed which showed a maximum of 57 amperes at 120 volts, making a maximum demand of 6.8 kilowatts and for 30 days 205 kilowatts as demand base. The customer's consumption was 742 kilowatt hours; therefore, we have

| | |
|---|---|
| 205 units at 16¢ | $32 83 |
| 537 " " 5¢ | 26 87 |
| | $59 70 |
| Less 15% discount | 8 95 |
| Net bill | $50 75 |

with minimum bill of $32.83. From the above customer it can be seen that the average price for current received by the company was .0683. The same customer with maximum demand on the "Forsee" system would get the following result:

57 Amp.; 114 16-cp. lamps, approximately.
114 16-cp. lamps at $1.50 per year = $171.00 (capacity charge), or $14.33 per month.

Consumption

| | |
|---|---|
| 742 at 6¢ | $46 52 |
| Capacity charge | 14 33 |
| Giving a net bill of | $60 85 |
| Average price for current | .0806 |

In a recent application for current we found the following condition: The customer desired to use 125 sixteen-candle-power lamps 13 hours per day, and on the yearly-demand contract we should arrive at the following result: one hundred and twenty-five 16-cp. 50-watt lamps 13 hours per day for 26 days would show a total consumption of 2,112.5 kilowatt hours. Thirty days of maximum demand of 6.2 kilowatts for one hour per day would make a base of

| | |
|---|---|
| 186 K.W. hours at 16¢ | $29 76 |
| 1926 " " at 5¢ | 96 30 |
| Total | $126 06 |
| Less 2% | 25 21 |
| Net bill of | $100 85 |

With minimum monthly bill of $29.76, average price the customer would pay for his current .0477 per kilowatt hour. The same customer on the "Forsee" system would be required to pay a capacity charge of 150 times $1.50 or $187.50 per year or $15.62 per month, and for his current 2,112.5 kilowatt hours at six cents, $126.75; making a total of $142.37 per month as against $100.85 on the demand contract agreement. Our plan was taken into consideration, whereas the amount that he would have had to pay for his current on the above plan would have been so high that it would have precluded the possibility of our getting so desirable a customer.

## ALEX. DOW

Mr. Doherty's premises are correct. His deduction therefrom that the sale of current at a fixed rate per kilowatt hour is as inequitable as the sale of current at a fixed charge per lamp, is fully warranted by the premises. His advocacy of the Kapp or Hopkinson method, which he has put into effect at Denver is reasonable; and I believe that he is warranted in assuming that a considerable portion of the new business obtained by his company is due to the method of making the rate rather than to the low actual rate which has been forced upon him by competition. I appreciate Mr. Doherty's frankness in attributing the increase of consumption largely to the adoption of the lower rates, and not peculiarly to the system of charging. In many cases, both in the United States and Great Britain, which have been recited as proofs of the advantage of the differential rate, the conditions so obviously required the adoption of a low rate that the manner of its adoption was of comparatively small consequence.

I am, however, of the opinion, after five years' experience with differential rates, that when a reduction of rate is to be made, it should be made in such manner that the reduction will apply on the business which is being done at a profit, and not on the business which is being done without profit or at a loss. The equity of the differential rate is expressed in the statement just made. The theory of equity requires that each kilowatt hour sold shall bring a uniform profit to the selling company. If any current is sold at a loss, a higher margin of profit must be taken on the business that is done at a profit; for it is certain that the customers must pay all the expenses of a lighting company, whether these expenses be standing charges or running charges; otherwise that company is running into bankruptcy.

Nevertheless, I must recognize that the ideal service is that which operates with constant load twenty-four hours a day, and that the ideal rate is that which is uniform to all users, regardless of the time of day or season of the year. We, therefore, should take advantage of every class of load which will straighten our load curve. The straightening may be done in some cases by obtaining a day load which is literally a day-light load, and can be switched off at dusk; in other cases—as in New York—by linking together districts whose periods of maximum load succeed one another; or possibly in the future, by using such a large proportion of storage battery that the inequalities are thereby done away with. I do not intimate that any of us can at present so straighten our load curve as to warrant a uniform rate. I say, however, that we should keep on trying to do so; that while recognizing the necessity and the equity of the differential rate under present conditions, we should persistently endeavor to so modify these conditions that the necessity for the differential rate will ultimately disappear.

MR. DOHERTY: I wish to explain that we tried to get someone to outline the Kapp or Hopkinson method, to which Mr. Dow refers, but we have not been able to find anyone at this convention who is familiar with it. It seems there are two systems; one by Kapp and one by Hopkinson. Two or three of our members know what the Kapp system is, but we can not find anyone who knows about the Hopkinson system.

CHAIRMAN HUNT: I am informed that Mr. Arthur Williams has a statement regarding the Hopkinson method.

MR. WILLIAMS: Before reading this memorandum, may I explain that it was written entirely from memory, and if anyone finds me in error I shall be glad to be corrected. I do not think there are any substantial errors.

### THE HOPKINSON METHOD

Dr. Hopkinson, early in his electrical career, recognized that the cost of current as supplied commercially was divided, broadly speaking, into two elements: the first, and by far the larger, including those costs incidental to the equipment and readiness of the plant; the second, those costs incidental only to the immediate generation of electric current. Interest, depreciation, up-keep expenses, the executive and office costs, and, I think, a certain portion of the station costs, were included under the first heading. Under the second were included purely operating expenses, such as labor, supplies and repairs, as needed in the actual production and supply of the electric current.

Dr. Hopkinson recognized that each customer subjected the company to costs of the first order in direct proportion to the extent to which an installation was connected; that, however, there were some whose use of artificial light was so limited—the short-hour users—that they could not be supplied at other than a loss unless a rate were adopted so high as to be unfair to other and better favored users. He therefore required that each customer should make two forms of payment for his service, corresponding with the divided cost of production as outlined in the foregoing. Each customer was compelled to pay a stipulated sum per annum (about $2.50 per each 16-cp lamp equivalent in our money, if I remember) for each unit of installation connected, and a very small sum, equivalent to about three cents per kw-hour, in addition, for the current actually consumed. Thus he planned as do Wright, Doherty, and others, though in modified and original forms, to avoid giving any service not alike fair to the user and profitable to the corporation.

MR. DOHERTY: Do I understand that the charge involved the capacity charge and the consumer's charge?

MR. WILLIAMS: A capacity charge based on the number of lamps connected, and a secondary charge based on the amount of current consumed. He first put the system into effect in Manchester, England; he at that time being consulting engineer of the Manchester works.

MR. DOHERTY: There is a distinction between his system and mine.

MR. WILLIAMS: While the subject of rates is before the convention, I want to suggest a method of charging, which, in view of what has been said, I am afraid will be at the moment unpopular. It is the adoption of a flat kw-hour rate, without discount, for all electric current supplied for the works. A rate on one scale would be appropriate for retail or limited users of light, another designed for competition with isolated plants for the larger users where the costs of supply are proportionately less; a third power rate is also desirable, which might be subdivided, wholesale and retail. Power continues every working day, usually without variation, and can as a rule be furnished at less than the cost of light.

We shall find, upon inquiry, that the conditions governing almost any large undertaking are in principle much the same as those governing our own, affording us a perfect analogy. The railroad, the hotel or restaurant, the dry-goods store, the gas supply—the so-called stand-by charges are relatively very high in all, while the actual supply or service charges are very small. You will find in all that the principle of the flat rate has been adopted. It seems to me that a method which attempts to divide the various expenses incidental to supplying a customer with electric current is very much like the European method of hotel charging, under which the room is one item, service and candles are others, and in the restaurant even bread and butter are separately charged for. Under the American system but one general charge is made, though one guest may consume more light or eat more butter than another; such conditions are covered in general averages, and the system, on the whole, is much more satisfactory. The electric light business should be conducted on the same principle. The Wright system is as nearly ideal as any system can be where it is desired to make an individual charge for each factor of service, and to make an exact profit out of each user. This system individualizes the generating or station costs and averages the costs incidental to the distribution of current; it will distinguish between the long-hour and short-hour user, and, therefore, the extent to which the station machinery is in demand, but not between a consumer who is 100 feet from the works and another who may be several miles away. Under any system that attempts to itemize the costs and to ensure the profits, the customer next the station is entitled to a very much lower rate than one far distant, yet neither the Wright demand nor any other system will make any such distinction.

Our experience has been that the user of electric light does not know or understand the unit charge any more than he knows the definition of the unit itself. He simply knows the amount of his bill from month to month and what corresponding gas or candle service would cost him. By making the rate low enough, he would be more than glad to use electric light exclusively, and that is all we can ask anyone to do. It has been maintained that there is practically no so-called "one-hour business" in any city on this continent, and this opinion is sustained by Mr. Ferguson's paper, in which he shows that only 3.65 per cent of his customers use current less than one hour per day. The use of light is controlled by a number of considerations: convenience, cheerfulness and advertising are three of them. One can hardly get enough light; if the price is sufficiently low; the restraint upon the use is lessened and the load curves are bound to broaden. I think it will be accepted as true that a high price means a very limited or low average use; a low price, a liberal or high average use.

Different factors control the use of current for power. Where electric power is consumed, its maximum as well as its minimum use is determined by the demands of the service. However great, power, with few exceptions, constitutes but a small percentage of the whole load cost of any manufacturing plant, and there is the same incentive to use the motor as to keep the employees at work. The two go together, and I think there is nothing that we can do, artificially, to stimulate the average use of current by our motors after we have made our prices competitive with other methods of obtaining power, such as foot-power, or the steam or gas engine.

Mr. Wright, the inventor of the Wright demand meter, is in charge of the Brighton, England, electricity works, and while visiting there some three years ago I thought that the use of electricity in that city seemed more general, particularly in the stores of the intermediate class, than in any other city that I had visited; yet, as a result of several inquiries among the poorer shopkeepers, I could only learn that they used electric light because, while much better, it cost no more than gas had previously cost. Not one of the users whom I saw seemed to understand the method—simply the result. It would seem that we should place ourselves in the position of making it as easy as possible for the general public to deal with us and to understand our methods and rates. Any system that requires a guarantee from a prospective user restricts the scope of the company's service, and any system that attempts to individualize the items that go to make up the total costs, in addition to being understood with difficulty, is difficult and expensive to maintain; and, after all, the result, in my judgment, is much less satisfactory and profitable than one where all those items are covered in the general charge and one customer is supplied at exactly the same rate as another.

Mr. Gilchrist: I think we will all admit that we have wished that our business were such that a uniform price, as suggested by Mr. Williams, might be charged; that is, without even dividing it into wholesale and retail quantities; that we might manufacture electricity as the gas companies manufacture gas—to sell it uniformly at so much per unit; but such is not the case. I think that New York conditions may tend more toward permitting that kind of rate than the conditions of any other city or town in this country. We must, in the opinion of most of us, have a system that will charge a higher rate to short-hour consumers and a lower rate to long-hour consumers, on account of the station investment, which may be the same in both cases although the consumption will be very different. That being the case, it seems to me that what the electric-light companies want is a system that will take care of that in the simplest and most automatic way; and if we can find a system that is automatic in its workings and conforms in a reasonable degree to varying conditions of the cost of manufacture of electric current, we should not hesitate to sacrifice a small percentage—if it be a small percentage—for the sake of the convenience to the customers and of the automatic character of the system. I should agree with Mr. Doherty if we were absolutely in a monopoly of the illuminating business; it would be ideal and absolutely equitable to charge every consumer a rate in exact proportion to the cost of producing his current; but in looking at Mr. Doherty's system largely from the position of a salesman, I should hate to undertake to push the business of the company I represent, in any such way as we should like to push it, using his system. I think that, while electricity has been before the public for 15 or 20 years and the public is more or less familiar with it as a commodity, yet there is a large class of the public that knows electricity simply as it is seen in the restaurants, theatres and public places. They do not know it in their own homes, and we must, for a time at least, conduct the extension of our business along educational lines; and we are warranted, in certain classes of business, in making inducements to develop consumption along such lines for the sake of broadening the business. In the Chicago Edison Company and the Commonwealth Electric Company, of Chicago, we charge a minimum bill of $1.00 per month to small consumers. We do not for a moment believe that where we have a kilowatt or two kilowatts' capacity connected and do not get a dollar a month out of the business, it is profitable business to us; and yet, to get business so small that a $1.00 minimum bill is a hindrance, we have adopted the use of prepayment meters with which we ask no monthly minimum bill. We use prepayment meters more as a pioneering scheme than anything else, putting them in many apartments where, as I say, we can not get people to face a $12 minimum charge per year. We know from experience that we shall get a reasonable income—very much more than that—out of them, and we want to get the business; but in order to get it quickly, and in order to avoid spending the time of our solicitors in going to see these parties week after week to induce them to take the light on a contract basis, we put in the prepayment meters. A party will burn 30, 50 or 70 cents' worth of light per month. That goes on for six months, and then we send a man to see the party who has the meter, and if this low consumption is kept on continuously and it is apparent that the man is simply making a convenience of us, we inform him that we can not afford to maintain our investment with that income;

out in 75 per cent of the cases we get these people, of their own volition, on our regular rates within a year and they become good customers. It is very difficult to induce them to assume the expense at first—or what they understand to be the expense—of the electric light, and while during the first six months or a year they burn the light sparingly, they gradually begin to look on the electric light more as a necessity than as a luxury, and their consumption increases greatly, so that a man living on the same income to-day as he did two or three years ago will perhaps burn three times the amount of electricity in his house that he did when he first put in the light two or three years back. We have a very large number of customers, and possible customers, who have just about one kilowatt capacity connected. They are in the smaller apartments, which are becoming extremely popular as places of abode in Chicago. I figure on Mr. Doherty's basis, taking the average case, that these apartments, having about 20 lamps, would be subject to a consumer's charge of $12; then add their minimum—20 lamps—at $1.80 each, making $36 per year, and it equals $48. They would probably use, at five cents per kw-hour, about $10 worth of current; so that we have $58 per year for that consumer. His consumption at 20 cents per kw-hour would be about $37.50, so you see he would be paying on Mr. Doherty's basis about 38 cents per kw-hour. We shall get that man, and his bills for the first year will be about $30, as he will use the current very sparingly. We have had difficulty in convincing him that he should use electric light; but although we have succeeded in convincing him that he ought to have it, it will not do to put him up against $58 a year to start with, because he has been paying only

$20 for gas. He may not be a very good customer the first year, but as he comes to consider electricity a necessity he will become more liberal in the use of it and will gradually work into being a good customer. Besides that, the business will rapidly spread. I mention this as one place where it would be very awkward to have Mr. Doherty's rate in force.

As to the users of light not understanding the Wright demand meter. Anyone who has used the Wright demand meter for any length of time and has seen the way in which a customer will come in and question the fact that his demand has been, say, 20 lamps as shown by the meter, and who figures out what the bill should be upon his own assumption of maximum, will see how very quickly men who are apparently not at all intelligent, but who, on the contrary, are rather obtuse, will grasp the broad principles of the system. I have a good many men come into the office who, when I ask them if they thoroughly understand the system, will joke about it and turn it off and say they do not; but our experience in dealing with them has shown us that such is not the case, and we have been surprised to see the ready way in which they grasp the principles of the scheme.

Mr. Isaac B. Smith (Cedar Rapids, Ia.): In answer to the gentleman who spoke last, I would say that it would not be possible in some places to take on a customer and determine whether he were profitable or not, and if it developed that he was not profitable then advise him that he must discontinue the use of the light. There are many ordinances that provide that you must furnish light to all consumers on the rate that the company has adopted. We ran up against that proposition—I think it was in 1894—at a time when we had a little experience in selling light on a meter basis solely. We at that time evolved the principles that I think are broadly outlined in both Mr. Doherty's method and in the Wright demand method. I think, however, that Mr. Doherty's method is the better one. I think, in the first place, that Mr. Ferguson should have consumer expenses provided for, and I think that fact was brought out yesterday in the discussion of the lamp question. A more efficient lamp will reduce your capacity charge but increase consumer expenses, because you will have to have more consumers using efficient lamps to consume an equivalent of current where inefficient lamps are used, and that means more expense. If we were operating on the Wright demand system in a small town of 30,000 inhabitants, with broad streets and buildings not so high as they are in large cities, with shade trees very numerous and the tendency of the people to sit out at night in the summer-time, it would reduce the summer load line very materially from what I know the Chicago Edison load line to be, and I think a manager will find it necessary to anticipate the demands of the station in the month of December.

In regard to Mr. Williams' suggestion as to charging the man who lives a long distance from the station more than we charge the man who lives a short distance away, that involves the question of distribution. If you are going to charge me, because I live near the station, less than you charge another man who lives further from the station, the first thing you know there will be another plant started up in the neighborhood of the man that lives furthest from your station.

Mr. Doherty says that he requires his people to make contracts in order to protect his station along the line of the principles he has evolved. We started out to do this, but waived the condition because we found that it was not necessary in practice. The differential rate is very simple. You have to estimate the number of burning lamps the consumer has, and make two multiplications instead of one. You can discount your base rate or discount your rate for current consumed, or both, when it is thought advisable to offer lower rates for service. We sell current as low as two cents per kw-hour in some cases. I ask Mr. Doherty what he does with the transmission losses. Is that a capacity charge, or does he consider it to vary with the generating expenses?

MR. FERGUSON: May I ask you to explain the system you have?

MR. SMITH: I call it the Doherty system.

MR. F. ELLWOOD SMITH (Somerville, Mass.): I have been interested in the Doherty method from the time Mr. Doherty introduced it, and also in the method advocated by Mr. Wallis. I have studied them both, and have been interested in the discussions that have taken place here; but I am glad to hear what Mr. Williams has said. I have been tending toward the same opinion he has expressed: that the more simple we can make the purchase of our light to our customers, the better it will be; that our business is an average business, and that we should not try to make each individual consumer pay for all the expenses occasioned by him. I think we shall gain in the end if we make a flat rate which, by employing a proper system of discounts, can be reduced to the different customers according to the quantity each uses. The table of discounts can be extended as far as may be necessary. I believe that the more simple we can make the business for the customer, treating it as an average business, the better it will be for all concerned.

Mr. E. A. Leslie (Brooklyn): I have been associated with the electric-lighting business for a good many years in an administrative and executive capacity and I recollect that in the early days, back in 1889, when I first joined the ranks, the question of rates was one of the most perplexing problems with which the electric-light men of that day had to contend. The business of electric lighting is very different from most commercial enterprises. The question of supplying the largest possible amount of his product at any given time of day does not confront the average business man, and therefore he does not have to take it into account; but that is one of the most important features of the electric-light business, and, consequently, ever since we have gone into the business of commercial lighting, that peculiar feature has been one of the most important factors with which we have had to deal, and it bears not only upon the subject of engineering, but upon rates as well. Now, I do not know whether or not you all appreciate the fact that Mr. Edison was the pioneer in rate-making. Possibly you do. I understand from the old Edison electric-light people of New York, where the first central station in the world was established, that Mr. Edison, when he decided upon the basis of rate, sat down and figured on the then cost of gas, $2.50 per thousand feet, the burner in use at that time consuming between three and four feet per hour, and a very poor burner it was. He took gas at $2.50 per thousand feet and divided the price by four, and brought out the fact that 1,000 feet of gas at $2.50 would be equivalent to a 16-cp lamp at a cent an hour; but because the gas burner ranged between three and four feet per hour and gave on an average 14 candle-power as against the 16 candle-power of the Edison lamp, he charged slightly in excess of one cent, saying that with the advantages of electric light over gas we could surely assume to charge at least as much as the gas companies received; and that was the basis of the first electric-light rating in the world. That rate was about 20.2 cents per kw-hour—a little over one cent per lamp-hour. Now, as the business increased, the gas rates declined, and it was not long before electric-light rates, instead of being upon a par with gas rates, were sensibly higher, and in order to develop our business we had to dwell particularly upon the advantages of electric light to induce the people to take it instead of gas, because of the greater expense. The gas people solved their rates long ago; the gas holder helped them to do it. Take the great plants in New York, Chicago, Boston or Philadelphia, or any of the large cities, and the gas companies at this time of the year are probably working with one shift, and with that one shift they put enough gas into their holders to supply the service for 24 hours per day. Later on, in the fall, when they need a larger output, they may run two shifts, without increasing their generating apparatus, and in that way serve the public to the extent of the demand. In mid-winter they may possibly run their plants 24 hours per day. Hence, it is clear, I think, that gas companies are justified in charging a fixed amount per unit of gas delivered, because of their simple operating problem.

There are three great points that bother electric-light men. The first is the matter of rates, to which I have given the preference; the others are the expenses and the gathering in of the business. To my mind, the gathering in of business is of first importance, although it may require less of the executive and managerial time than either of the other divisions. We know that when we can get star performers, such as are present in the room at this time, and say to them, "Go out and get the business," they will go out and get it, and it will roll in over the counter and puzzle the engineering departments to keep pace with it. In some of the great centres of the country the engineering departments have not been able to keep up, but are distinctly behind. Their operating expenses are increased by reason of the fact that they have not been able to keep pace with the demand. I remember distinctly that in my earlier days the expenses were rather a negligible quantity; that if we got in a big lot of business, the fact that our expenses were creeping up larger in proportion than the actual growth of the business, did not seem to be appreciated. I must say, with respect to myself, that it was a trip to Europe some years ago that opened my eyes in that respect. I found that over there they made the expenses of the company the subject of more careful study and consideration than any other feature of their business, so that whatever their gross income, their net income should represent the largest possible amount that they could save; they were economical—that was the great point.

I think these discussions on rates, which have been going on since 1889, and possibly longer, are due, as I said before, to the peculiar nature of our business. We can not say—any of us—that we can make a rate that will be the available rate for any city in the United States or any other country. We find that Mr. Insull, in Chicago, will disagree with Mr. Murray, in New York, on some feature of the rate question, and Mr. Edgar, of Boston, will in turn disagree with both on certain features, while Mr. Doherty, of Denver, will possibly disagree with all the rest of them on other features; so this rate question can not be cleared up to-day by any one man in this business. If a man could clear up this question, I should be inclined to rank him with the great geniuses that this magnificent industry has produced. I contend that until our engineering problems get along to a point where we are more nearly on the same basis with the gas business, there is not one of us who can say what should be the "universal" rate. Nevertheless, I appreciate the fact that these discussions, and these schemes that are brought out from time to time, are productive of good and will eventually solve the problem.

CHAIRMAN HUNT: We will close this discussion by calling on Mr. Ferguson, Mr. Wallis and Mr. Doherty.

MR. FERGUSON: I think, gentlemen, that it is too bad that this association can not rise beyond the dark ages. I think I have heard arguments to-day that put us back fifteen or twenty years in the business. We have one of our members coming here and advocating a uniform price to all. That, gentlemen, is carrying us back fifteen or twenty years. We have been struggling for ten years to get beyond it. We have worked gradually; the rate methods of to-day are matters of evolution. We have shown the gas people that their method is wrong. All you have to do is to look into any of the cities of the country and see to what the gas business has been forced. It has been driven from the centres of the cities to the outside sections. Why? Because of the variable rates made by electric-light companies. Are we going back again to the point where we were fifteen years ago, with our 1.2 cents per lamp-hour, or are we going to progress as we have done for the last ten years? I said in my printed discussion that the production and sale of electricity differed from those of any other business in that the electric-light company must manufacture its product only as it is required, and it can not be commercially stored. I do not say that with any intention of belittling the storage battery, but the storage battery is not like a gas holder in its relation to electricity. It is a different proposition, consequently the company's plant and mains must be governed by the maximum demand on them at any one time. Another strong point against the advocates of uniform price is this fact: the customers will not wait for the supply, and can not be prevented from taking it when they desire it. If you go into a large mercantile establishment and buy five dollars' worth of goods, you do not get the goods immediately; you have to wait until the merchant is ready to deliver them. If you want electric light in this room, as we want it at this moment (the lights in the room were at this instant turned on), the light is turned on; and the station does not control it—you get it immediately. A further claim that I have made regarding a uniform price is that it is unjust; it is unlawful, and I think that it can be so proven. I have before me legal decisions on this point. Mr. Williams advocated two uniform rates; one for large consumers and another for small consumers. I can prove by several cases that this is unjust discrimination. The decision in the case of the I. C. R. R. Co. *v.* People, 121 Ill. 310, says, "Discrimination based upon the quantity of service is just, when the discrimination is made proportionate to the decreased cost per unit of performing the larger service." A decision in Hays *v.* Penn. Company, 12 Fed. 309, says, "But discriminations based solely upon the quantity of service, without any reference to conditions tending to decrease the cost of the service, are unjust." There is a justification for variable rates and equitable tariff, such as Mr. Doherty recommends and such as the Wright demand system recommends. These two systems are so similar that you can hardly tell them apart; as there is no difference in the principles underlying both methods; the only difference is in their application. In defense of the legality of the variable tariff, such as Mr. Doherty recommends and the Wright demand system recommends, I will read part of the decision from Smythe *v.* Ames, 169 U. S. 466: "Neither the state nor the city can, however, prescribe such charges as will not admit of the company earning such compensation as, under all the circumstances, is just to it and to the public, as by so doing they would deprive the company of its property without due process of law, and deny to it the equal protection of the fourteenth amendment to the Constitution of the United States. It is for the courts to determine ultimately whether such charges are reasonable." The following citations are from Hutchinson on Carriers, Section 302, and are supported by a large number of decisions: "It is a rule of the common law that parties carrying on business which is public in its nature, or which is impressed with a public interest, can not select their patrons arbitrarily, but must serve all who apply on equal terms and at reasonable rates." And further: "This rule does not necessarily mean that there must be absolute uniformity of rates in all cases. It simply requires that there shall be no unreasonable and hence no unjust discrimination. It only becomes such when discrimination is made in the rates charged for goods of the same class under like circumstances and conditions."

Mr. Wallis: There is but one wholesale and retail method that will apply to this business, and that is, not the quantity of current consumed by any customer, but the hours' use. Minimum hours' use is retail, and maximum hours' use is wholesale. It is not necessary for me to say this; you all know it. Many people advocate giving customers a discount according to current used, regardless of how it is used. A man using 100 lights one hour per day, at one cent per hour, will pay $1.00 per day, or $30 per month. Another man using 10 lights 10 hours per day, at one cent, will pay $1.00 per day, or $30 per month. Now, if you give them the maximum discount of, say, 50 per cent, they will each pay you $15 per month. I have had all I want of that. I am satisfied with my plan in my territory; it has increased my business and my net income. My plan does not differ essentially from Mr. Doherty's, nor does it differ very much from the Wright demand. The Wright demand system, as it was introduced to me before I operated upon it, called upon the consumer to pay for a certain number of hours, according to his demand, whether he used the current or not. That seems to me unjust, and to a certain extent illogical. I understand that the Chicago company does not do that; neither did I; I could not. I increased my customers' bills after I told them I had a scheme to give lower prices. I found, further, that the Wright demand meter and system did not apply to short-hour consumers, and did not make long-hour consumers out of short-hour consumers. I argued the Foresee plan before the Gas and Electric Light Commissioners of Massachusetts, and compared my plan with the Wright demand, and I pointed out wherein my plan was more equitable than the Wright demand. The Wright demand meter caused a great amount of dissatisfaction among our customers, because they were not maximum users of current but might be maximum users of capacity; and, as a result, when their consumption exceeded so many hours' use of the demand they earned a discount, and when it did not exceed the demand we did not get the return our contract called for by the Wright principle and plan. I do not think I care to take more of your time. I thank you.

MR. DOHERTY: I, like the gentlemen who have preceded me, wish to take as little time as possible. I will first briefly answer some points brought up by Mr. Ferguson. I fear the conditions in New York and Chicago do not give a man such scope for rate-making as those existing in western central stations. The long-hour use in Chicago is due entirely to local conditions. We get none of that in the small western cities with wide streets and clear skies and conditions of that kind, which do not exist in Chicago. Mr. Ferguson says that he must not charge more than 20 cents per kw-hour; yet he brings up a legal decision very similar to one I was going to quote (and it is similar to many other cases), in which the court held that no concern is compelled to furnish service at a loss. In my own mind, if they contract to furnish, they will perhaps have to carry it out; but I do not think we can be compelled to furnish electric service at a loss. When a man puts in his own isolated plant, he has to fix his demand five or six years in advance; and if he can fix it for himself, I can not see why he can not fix it when he makes a contract with a central station.

I have no criticism to offer upon Mr. Wallis' system. I should have mentioned that in Mr. Ferguson's system the same consumption per yearly demand may cause one man to pay more than another, although the conditions are just the same; that is, in taking a monthly demand you can not make the Wright demand system entirely fair, and therefore you must take the maximum yearly demand; that is what you must settle upon. I wanted to have quite an argument with Mr. Ferguson, but if it comes down to the point where we must consider whether we will have the two-rate system or the uniform-rate system, there can be no quarrel between us, as any system is better than the uniform kw-hour system. I think the uniform system can hardly be classed as anything less than absurd. I object to the system of Mr. Wallis, because he does not differentiate between the capacity used by several consumers and that used by one consumer.

In answer to Mr. Smith, I will say that the resistance loss is taken care of, I think, in my capacity charge, which you will find outlined in the paper that I read before the 1900 convention. You can not place it exactly right; but there is no reason, if it can not be exactly right, why we should say let us be all wrong. I have been interested in both the gas business and the electric-light business for a period of twenty years. The main argument is that because the gas companies are wrong, we should be wrong. That is a poor argument. Within five years every gas company in this country will be convinced that the uniform rate of charging is the wrong rate, though their conditions permit it to a greater degree than any other business of a similar character. At the Ohio gas-light convention held in March, many of the leaders in the gas business agreed that a uniform rate was wrong—that it did not develop the business and that it was not equitable; and the fact remains that every electric-light company in this country is practically supported by those who were formerly the gas companies' consumers. Mr. Williams says there is absolutely no such thing as consumers who use less than one hour per day on an average.

Mr. Williams: A very small percentage.

Mr. Doherty: In Denver, the users who average less than one hour per day are 34.1 per cent. Of the users of light in Quebec, 60 per cent use less than 50 minutes per day. In Madison, Wisconsin, 40 per cent use less than one hour per day. These figures are approximately exact; the Denver figures are exactly right. Mr. Gilchrist objects to my system from the standpoint of the salesman. I do not see the difficulty; I say to a customer: "You know what the flat rate is; if your bills are $5.00 per month and no more, you understand it." We tell the people that we will serve them at $5.00 a month, and whatever current they use will be at five cents per kw-hour additional. We have difficulty in getting an unprofitable customer to pay enough to make him profitable, and we do not want him if we can not get him on these rates; not exactly on these rates, but on these rates if we could apply this system universally. It is not possible, because we have not educated the people aright, and we can not make a revolution in a day. Our customers like the system. The $1.00-per-month minimum charge is inequitable. Take a consumer with one lamp; that man is paying $1.00 minimum per lamp per month. Take the man with 800 lamps (I have a case where there is a big factory with 800 lamps), and if you give him a charge of $1.00 per month as a minimum, he is paying one-eighth of a cent per lamp per month; and yet that particular factory uses light only a portion of December and all of November, as, owing to the peculiar conditions under which they run, they need no light at other times; and when they use it, it is only for a short time each day.

CHAIRMAN HUNT: Before we proceed to the next papers, we will hear the report of the committee on resolutions.

MR. DAVIS: The chairman of the committee is absent, but the committee has drawn up some resolutions, which I will present. We hope no one has been overlooked. If anyone has been overlooked, we shall be glad to have our attention called to the fact.

### REPORT OF THE COMMITTEE ON RESOLUTIONS

GENTLEMEN: Your committee on resolutions begs to offer the following:

*Resolved*, That we extend to our retiring president, Mr. Henry L. Doherty, and the other officers of the association, to the members of the executive committee, and also to the assistant secretary and treasurer, our hearty thanks for the able and efficient manner in which they have discharged the duties that have devolved upon them;

That the thanks of the association be also extended to the ladies' reception committee, which has so pleasantly entertained the visiting ladies of the convention. Also to General Hickenlooper for his cordial address of welcome; to the Cincinnati Gas and Electric Company, the Cincinnati Street Railway Company, the Bullock Electric Manufacturing Company, and the Itannicnic Club, for the courtesies received from these various organizations, all of which have been much appreciated and enjoyed by our members;

That the thanks of the association be extended to the daily press of Cincinnati for the very complete and accurate reports that they have published of the proceedings of the convention; to Dr. F. A.

Wolff, of the National Bureau of Standards of Washington, for his interesting address, and to the gentlemen who have prepared the various papers and answers to questions that have been read at this convention, which have been so instructive; also to the several companies and their representatives who have contributed so much to the success and value of this meeting by their exhibits and their participation in the discussions.

Respectfully submitted,

Committee, A. M. Field, Chairman,
W. P. Conover, Jr.,
Ernest H. Davis.

(The report was unanimously adopted.)

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### REPORT OF THE COMMITTEE ON MEMORIALS

Gentlemen: Your committee on memorials begs to present the following resolutions:

Whereas, The National Electric Light Association, in annual convention assembled at Cincinnati, Ohio, May, 1902, has placed on record with deep regret the death of Mr. Frederick A. Gilbert, president and general manager of the Boston Electric Light Company, and

Whereas, Mr. Gilbert was formerly vice-president of the association, and was always interested in its success and welfare, it is hereby

*Resolved*, That it becomes the association to express its sense of the loss, to itself and to the electrical arts, of this big-hearted, enterprising leader of men, who was always willing to aid his associates in the time of their need, and who was distinctly of the type of men who have made electrical applications a success in America; and it is further

*Resolved*, That the secretary of the association be, and hereby is, instructed to convey to Mr. Gilbert's family and associates these heartfelt sentiments of sympathy and loss, and that they be duly entered in the minutes of the association.

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WHEREAS, The National Electric Light Association, in convention assembled at Cincinnati, Ohio, in May, 1902, has learned with regret of the death of General C. C. Howell, vice-president and general manager of the Knoxville, Tennessee, Electric Light and Power Company, and a member of the executive committee of the association, be it

*Resolved*, That the association place on record its sense of loss and its deep appreciation of the valuable and untiring efforts of the deceased in its behalf during a business career which exhibited him also as an able and broad-minded citizen of Knoxville; and be it further

*Resolved*, That the secretary of the association be, and hereby is, instructed to convey its sympathy and regrets, with the above sentiments of esteem, to General Howell's family and friends and to the Knoxville press; and that they be duly recorded in the minutes of the association.

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WHEREAS, The National Electric Light Association, in annual convention assembled at Cincinnati, Ohio, May, 1902, has received the sad news of the death of Mr. George B. Neal, one of the familiar attendants at its meetings and a valued member, it is hereby

*Resolved*, That the association express its regret at missing from its gatherings the face and voice of one who contributed so much to its success and who was ever ready with time, money and ideas to help in its work; and be it further

*Resolved*, That the secretary of the association record these resolutions on the minutes and convey them, with appropriate sentiments of sympathy, to the family and friends of the deceased member.

WHEREAS, The National Electric Light Association, in annual convention assembled at Cincinnati, Ohio, May, 1902, has learned of the death of Mr. S. S. Sias, a valued member of the organization, it is hereby

*Resolved*, That the deep regret of the association be expressed at the loss of this quiet and earnest worker, one of those whose united efforts made possible the success of the association and the spread of its influence; and be it further

*Resolved*, That the secretary of the association be, and hereby is, instructed to record these resolutions in the minutes of the association and to convey them to the family and friends of the deceased member.

Respectfully submitted,

Committee,
ERNEST H. DAVIS, Chairman,
F. ELLWOOD SMITH,
HENRY M. MOSES,
W. E. MOORE.

(The report was unanimously adopted.)

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Mr. J. F. Dusman, of York, Pennsylvania, presented the following resolutions:

*Resolved*, That the association accept the third progress report of the committee for investigating the photometric value of arc lamps, as read by Professor Matthews;

*Resolved*, That the same committee be continued, if possible, and if not, that another committee be appointed by the president to continue this work;

*Resolved*, That a vote of thanks be extended by this association to Professor Matthews for the most excellent developments and investigations shown by this report, and that the association request Professor Matthews, through its committee, to continue these investigations through the following year.

(On motion, the resolutions were unanimously adopted.)

THE SECRETARY: The question of what action should be taken in regard to the action of the National Board of Fire Underwriters, has been brought up, and the executive committee has adopted the following resolution, which is presented to you:

*Resolved*, That the amendment to the National Electrical Code proposed by members of the Underwriters' National Electric Association, and now being considered by the American Institute of Electrical Engineers, limiting the difference of potential in all overhead alternating circuits to 3,500 volts, is uncalled for and should not be adopted. Good and safe construction, rather than a limitation of voltage, is what should be insisted upon for all overhead electric lines.

(On motion of Mr. Doherty, the resolution was unanimously adopted.)

CHAIRMAN HUNT: We will now hear the papers on "Hot-Water *versus* Steam Heating."

# HOT-WATER VS. STEAM HEATING

J. F. PORTER

Our heating plant was constructed and placed in operation in October and November, 1899. We at first constructed about 3,000 feet of mains and connected therewith the business houses to which we had run the lines. The satisfaction of our customers was such that during the following year we extended our lines to the residence district, which is situated on the hill above the business portion of the town. Our present expansion tank is located on a high point, above all radiators, and is 140 feet above our pumps.

We now supply about fifty thousand feet of radiation, placed in residences, business houses, offices and schools, and where the amount of radiation installed is sufficient to counteract the exposure the system is giving most excellent satisfaction. As we have used no live steam, and the repairs for two years have amounted to less than four hundred dollars, we consider that our investment is very fair and will be more desirable as time passes.

During the first two years we operated our plant without any back pressure on our engines; but owing to the increase in the number of feet of radiation, and the severity of the past winter, we found it necessary to weight our back-pressure valve until the gauge showed three to five pounds during the period when there was but little electric light and power load, but during the late afternoon and until midnight we found that we had ample steam to furnish heat without back pressure on the engines. We originally installed a hot-water system, instead of an exhaust-steam, because of the fact that no back pressure was required, and by returning the water to the power plant we retained all the heat units not actually thrown off for the purpose of earning revenue.

We find that if we send the water out at 200° we have, at a distance of two thousand feet from the power house, a temperature of 198° where the water leaves the main line to enter the service of the customer. We also find that when the water is sent out at 200° and passes through the radiators and returns to the power house, our loss varies from 30° to 50°, depending upon the outside temperature.

We have experienced very little trouble from leakage on our pipe system, our only loss to mains and service pipes being caused by surface water passing through the sandy covering and corroding the pipe on its exterior.

We have had some difficulty because of our allowing parties to install less radiation than our figures would indicate, or because of the fact that the piping was imperfectly proportioned.

Everything considered, we believe that a hot-water heating plant with sufficient capacity to use the exhaust steam of a combination railway and lighting station will prove satisfactory to the operating company.

### P. H. KORST

In making our investigations as to the best system of central-station heating to install, we were influenced by the following points in favor of hot water:

Utilizing exhaust steam without putting back-pressure on the engines; even being able to run engines condensing, passing the exhaust steam through a circulating water heater on its way to the condenser. We have not tried this yet, but are guaranteed to be able to maintain a temperature of 160° in the circulating water and have a vacuum of eighteen inches on the engines. Doing away with back-pressure and the ability to run engines condensing mean a large saving in fuel.

With exhaust-steam heat a temperature of 212° or more is obtained whenever there is steam on, and for fully three-fourths of the heating season this is much more than is needed. Again, much heat and pure water is lost when the condensation is wasted in the sewers. With hot water the temperature of the water can be varied to suit the outside temperature, and thereby gives the customer an even heat. The condensed exhaust steam in the heater can be returned to the boilers after trapping out the oil, if the engines are running non-condensing.

From the customer's standpoint the well-known advantages of hot-water heating, such as the ability to maintain an even, mild, steady temperature, nearer to Nature's summer product than any other artificial heat, and to have just the right amount at the right time and place, make it worth much more than other forms of heating. Absence of noise, water hammer, odor, air in radiators, are also good features, and are talking points with prospective users.

The large amount of water in the pipes and radiators makes a certain amount of storage capacity for heat, and a system may be stopped in emergencies with a very gradual cooling of the water. Fuel economizers can be used to impart some heat to the water, and live-steam heaters are generally used to add extra heat in very severe weather and also at times when not enough exhaust steam can be obtained. In a hot-water system with a forced circulation, no attention need be given to the grade of the flow or return pipes, which simplifies and cheapens the installation. If a closed system is used, that is, one not open to the atmosphere at any point, the circulating pumps take only enough power to overcome the difference in pressure between the water in the flow and return pipes, or just enough to overcome the friction of the water in the pipes. In an open system, in addition to this, enough pressure must be used to raise the water to the highest point on the system.

Proper insulation of mains and service pipes is a simpler proposition with hot water than with steam, on account of the lower temperature, which permits the use of efficient material that would deteriorate under the higher temperature of steam heating.

Our customers, after two seasons' use, are highly pleased with the service and recommend it to all inquirers. They say they would willingly pay more rather than be without it.

The convenience of handling and the absence of dirt, ashes, smoke, odor, and noise are as strong features as are similar good points in electric lighting, which make the latter worth more than our competitors' lights. It is easier to induce a heating customer to become a consumer of electricity as well, since satisfactory service in one line makes him more receptive for good service in another.

There is some question about the method of charging. Some sell heat as they would light, by meter, having a fixed charge per square foot of radiating service installed for the season. The customer can regulate the expense by the amount of radiation installed. If he has not enough radiation, he necessarily does not keep his place up to a comfortable temperature; like a dimly-lighted store on account of too few lights. These people are always a thorn in the flesh of the central station man, for not only do they frequently telephone to see if we will not raise the temperature of the water, but they do not give the real reason to people asking why the store is cold, and thereby discredit the system.

The other method is to charge according to the cubic contents of the space to be heated, with additions for variations in exposure of walls, etc., and then install enough radiation to keep the rooms comfortable at all times. This is the more satisfactory system, but usually makes the cost of heating exceed considerably that obtained with stoves or furnaces, since a prospective customer will not always admit the greater worth of a heat that is uniform throughout the building and always in just the right quantity.

After one season the numerous advantages of buying heat from a central plant will soon make themselves manifest, and plenty of business will come in unsolicited.

## C. R. MAUNSELL

### FIVE YEARS' OPERATION AT TOPEKA, KANSAS

In a paper presented last year, a few facts and figures were given in regard to the investment in a steam-heating system and its effects on the lighting and power business. In the case of the Topeka plant it has proven a particularly good investment, and we hope many will be interested in the following data.

After five years' operation, we now have invested about one-sixth of our total investment in the steam-heating system, which consists of sixty-five feet of twelve-inch pipe, 420 feet of ten-inch pipe, 4,275 feet of eight-inch pipe, 690 feet of six-inch pipe, and 480 feet of four-inch pipe; a total of 5,935 feet of street mains, thirty meters and a few service connections.

Taking into consideration the cost of coal, inspection and all other expenses outside of station for a period of five years, the cost of operation has been thirty-seven per cent of the gross revenue. These expenses do not take into consideration extra wear and tear on boilers, nor any increased labor in the station. The effect on the boilers might properly be considered, but would be only an estimate at best. In our station, no increased labor has been necessary. We use coal-handling machinery and stokers.

The effect of back pressure while operating a steam-heating system is not such a serious matter as many have been led to believe, and we think you will agree with us on this point after a consideration of Table A, which gives the number of hours and the pounds pressure carried on mains.

## TABLE A

POUNDS PRESSURE CARRIED ON EXHAUST HEATING SYSTEM AND NUMBER OF HOURS CARRIED FOR SEASON OF 1901 AND 1902

| Pounds Pressure | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | |
|---|---|---|---|---|---|---|---|
| No Steam | 148 | 4 | ... | ... | ... | 12 | 164 |
| Exhaust | 432 | 168 | 16 | 40 | 12 | 204 | 872 |
| Exhaust to 2 pounds | 40 | 136 | 64 | 68 | 32 | 116 | 456 |
| Exhaust to 3 pounds | ... | 52 | 120 | 80 | 64 | 44 | 360 |
| 1 pound | 4 | 56 | 64 | 60 | 24 | 44 | 252 |
| 2 pounds | 116 | 152 | 112 | 120 | 112 | 176 | 788 |
| 3 " | 4 | 144 | 172 | 120 | 84 | 112 | 638 |
| 4 " | ... | 8 | 56 | 136 | 136 | 24 | 360 |
| 5 " | ... | ... | 48 | 36 | 76 | ... | 160 |
| 5½ " | ... | ... | 76 | 60 | 112 | 12 | 260 |
| 6 " | ... | ... | 16 | 24 | 20 | ... | 60 |

## SUMMARY OF TABLE A

### AVERAGE PRESSURES AND HOURS CARRIED

| | Av. Pressure | Exhaust | No Steam |
|---|---|---|---|
| October, 1901, 164 hours........... | 2 lbs. | 432 hrs. | 148 hrs. |
| November, 1901, 548 " ........... | 2.2 " | 168 " | 4 " |
| December, 1901, 728 " ........... | 3.1 " | 16 " | ........ |
| January, 1902, 704 " ........... | 3.17 " | 40 " | ........ |
| February, 1902, 660 " ........... | 3.66 " | 12 " | ........ |
| March, 1902, 528 " ........... | 2.4 " | 204 " | 12 hrs. |

The engineers regulate the pressure by Schedule C, which was compiled in accordance with the outdoor temperatures, this being the varying factor. The average temperature for this locality during the months from October to May, inclusive (which is our heating season), as taken by the Government Weather Bureau from twenty years' records, shows 43.9° above zero. The past five years being the time referred to, Table B shows the average temperature for each month and year during this period.

## TABLE B

### AVERAGE TEMPERATURES FOR THE CITY OF TOPEKA AS TAKEN BY THE UNITED STATES WEATHER BUREAU FOR THE PAST FIVE YEARS

| | 1897 and 1898 | 1898 and 1899 | 1899 and 1900 | 1900 and 1901 | 1901 and 1902 |
|---|---|---|---|---|---|
| October.................. | 63.1 | 53.6 | 63.0 | 62.8 | 60.8 |
| November............. | 43.9 | 39.4 | 49.8 | 41.6 | 44.2 |
| December............... | 28.2 | 27.5 | 30.3 | 35.7 | 28.7 |
| January.................. | 31.7 | 30.5 | 34.1 | 33.3 | 30.4 |
| February................. | 35.9 | 18.9 | 24.8 | 26.3 | 22.2 |
| March .................... | 43.8 | 34.6 | 41.0 | 42.2 | 45.2 |
| April ...................... | 53.0 | 53.6 | 57.4 | 53.4 | .... |
| May..................... ... | 63.3 | 67.8 | 66.3 | 63.4 | ... |
| Average for season...... | 45.37 | 40.7 | 45.95 | 44.84 | .... |

## AVERAGE TEMPERATURES FOR THIS LOCALITY FOR THE PAST TWENTY YEARS, FROM UNITED STATES WEATHER BUREAU, FROM OCTOBER TO MAY, INCLUSIVE

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| October, | 56.° | December, | 34.8° | February, | 31.2° | April, | 56.8° |
| November, | 41.2° | January, | 26.8° | March, | 41.° | May, | 63.4° |

Average, 43.9°.

The engineer's schedule has been determined by experience of what steam pressure was necessary for each consumer if his piping was in the condition required by us. (See specifications.)

## TABLE C

### SCHEDULE OF STEAM PRESSURES, FOR RUNNING ENGINEER, TO MAINTAIN ON EXHAUST-STEAM-HEATING SYSTEM, IN ACCORDANCE WITH OUTSIDE TEMPERATURES.—ABOVE 70° NO STEAM

| Temperature Degrees | 5:30 A. M. to 6 P. M. | 6 P. M. to 11:30 P M. | 11:30 P. M. to 5:30 A. M. |
|---|---|---|---|
| 68 to 55........ | Exhaust only | .......... | .......... |
| 54 to 40........ | 2 pounds | Exhaust to 2 pounds | Exhaust only |
| 39 to 28........ | 3 pounds | Exhaust to 3 pounds | 1 pound |
| 27 to 19........ | 4 pounds | 4 pounds | 2 pounds |
| 18 to 9........ | 5½ pounds | 5 pounds | 2 pounds |
| 8 to 0........ | 5½ pounds | 5 pounds | 2 pounds |
| 1 to 10 below.. | 6 pounds | 6 pounds | 3 pounds |

NOTE.—"Exhaust only," means NO PRESSURE WHATEVER. "Exhaust to any pressure," means NO LIVE STEAM TO KEEP PRESSURE. Where pounds of pressure are given, if the exhaust is not sufficient, supply with live steam.

From Table A it will be seen that the maximum back pressure is required but a few hours during the heating season of 5,760 hours, or eight months. Therefore it need only be considered from the standpoint of the capacity of the engines, if the revenue will pay for all coal used and also interest on the investment. To illustrate this point, you will note that for only sixty hours last season was it necessary to carry the maximum, six pounds pressure.

Our system consists of 12,763 square feet of radiation in mains, 1,640 square feet of radiation in service pipes, 8,640 square feet of radiation in covered piping in buildings not charged for, and 67,239 square feet of radiation charged for. This radiating surface heats 6,528,475 cubic feet of space. The amount of steam condensed per square foot of radiation during the heating season, as measured by the water meter, we have found to be 360 pounds; this equals at meter rate of sixty cents per 1,000 pounds of water, about twenty-two cents per square foot of radiation. Two thousand eight hundred feet is the greatest distance from the power house to which steam is supplied.

We have found it good practice to keep a card system of diagrams, which is practically a floor plan of the consumer's premises, locating pipes, traps. meters and radiators

To enable us to operate at a minimum pressure, it is essential that all building installations be under our supervision, and we have a set of specifications for steam-fitters, a copy of which is embraced herein.

### SPECIFICATIONS FOR STEAM HEATING SYSTEM

Service connection will be made at the expense of the consumer.

Size of surface pipe, and the manner and place of connection, must be obtained by application to the company when permit is issued.

Where it is necessary to tap the street mains, the iron pipe must be wrapped with an asbestos paper, held in place with a copper wire, and the pipe covered by a tin-lined log of the same character as used in our underground mains, and the log covered with three-ply tar felt, the log to extend to the inside wall of the building. Any joints made in log must be covered by cement brick work, and filled with sawdust to prevent the surface water coming in contact with steam pipe.

All the new work must be done on one-pipe, low-pressure loop system, and so arranged that one trap will empty all water of condensation into a cooling coil, and thence to the sewer.

The service pipe must have a gate valve placed as near the point of entrance to the building as possible.

The grade of pipes must be such that all water will run freely from service valve back to street mains and from service valve toward steam trap; where mains can not be so arranged, a drip pipe must be connected direct to steam trap.

All pipe must have adjustable pipe hangers of approved type well secured to ceilings.

Branches or risers from mains to upper floors and each radiator must have cut-off gate valves placed where they leave the mains. All branch pipes must be one size larger than risers. Risers to be fitted with ceiling plates where necessary.

Steam traps must be as simple as possible, and easily taken apart to clean; they must have automatic air vents with positive opening.

There must be a cut-off valve in the return line at the trap, so that steam can be shut off while trap is being cleaned. Following traps must be used:

| Square Feet Radiation | Size Inlet | Size Outlet |
|---|---|---|
| Up to 700 feet | 1¼ inch | 1 inch |
| 700 to 1,750 " | 1½ " | 1¼ " |
| 1,750 to 3,000 " | 2 " | 1½ " |

*Tell Tales*—A piece of one-fourth-inch pipe twenty-four inches long must be placed in the discharge line after leaving the trap, and the upper end left open so that if trap does not work properly steam will issue to notify consumer of the fact.

*Cooling Coils*—A cast-iron continuous coil with square feet of heating surface equal to one-fifth of the total heating surface installed in the building, must be placed in the discharge line of steam trap, and provision made for passing cold air over the coil and thence to a register placed at some point where heat will always be needed when steam is on the system. The box containing this coil must be lined with tin and the coil so placed in it that the air will pass over each section and not along the sides of the box.

*Meters*—When a consumer desires to use meter system, the steamfitter will be required to furnish the pipe fittings but the Edison Company will set the meter.

*Pipe Covering*—All pipes and fittings not intended to be used as heating surface must be covered with approved pipe covering; same to be not less than three-fourths of an inch thick.

*Radiators*—All pipes and valves to radiators must be as follows:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Radiators | up to 35 | feet, | 1 | inch | valve | and | pipe |
| " | 40 to 55 | " | 1¼ | " | " | " | " |
| " | 60 to 70 | " | 1½ | " | " | " | " |
| " | 75 to 125 | " | 2 | " | " | " | " |

All radiators must have air vents placed on the opposite end to feed pipe at least twelve inches above the floor.

*Painting and Bronzing*—All radiators and exposed pipes should be painted or bronzed as the consumer may require.

*Measurement of Pipes*—Steam fitters, in computing the square feet of heating surface in piping, will use the following table:

MULTIPLY THE TOTAL LENGTH OF PIPE BY THE DECIMAL FOR EACH SIZE OF PIPE

½ inch, .22; ¾ inch, .275; 1 inch, .344; 1¼ inch, .434;
1½ inch, .497; 2 inch, .621; 2½ inch, .753; 3 inch, .916;
3½ inch, 1.047; 4 inch, 1.178; 4½ inch, 1.309; 5 inch, 1.456;
6 inch, 1.734;

The steam fitter will be required to make a complete report on the permit blank issued by the company, and steam will not be turned on until this report is made and all appliances and workmanship have been approved by the company's inspector.

It was to the advantage of the public and the company to issue a pamphlet, "What to do to obtain steam heating from the Edison Company."

If the building to be heated has no steam pipes nor radiators, get a set of specifications from the Edison Company, and ask your plumber or steam fitter to give you the cost of the installation.

The service connection from the steam mains to the house piping is to be paid for by the consumer, and all the inside piping, radiators and necessary appliances are to be owned and maintained by the consumer, with the exception of meters, which are the property of the Edison Company.

Steam is supplied by flat rate (yearly contract), or by meter system on the following conditions: If the building to be heated contains a store room on the first floor and offices or living rooms on the upper floors, the company will contract with the tenant of the store direct, but will in no case furnish steam to the tenants of upper floors unless the owner of the building will sign a contract for the heating service.

Where the building is large and occupied by transient tenants, such as offices, hotels or living apartments, the meter system is recommended.

No building to which a service pipe and trap are required will be supplied with steam unless a minimum of 100 feet of heating surface is paid for.

If steam is wasted by consumers not turning off radiators in moderate weather, the company reserves the right to charge by meter.

Buildings to be heated from our street mains must have sufficient radiating surface so that they can be heated to a temperature of 72° in zero weather with a steam pressure of two pounds, and in no case will an installation for heating be accepted unless there is one square foot of heating surface for each 100 cubic feet of air space. The number of feet of radiation required depends entirely on the exposures and construction of the buildings, and one foot of radiation is sometimes required to each fifty cubic feet of air space.

The water of condensation must all be carried to a cooling coil, this coil to contain at least as many feet of surface as one-fifth of the radiating surface contained in the total installation of the building. After the water has been through the cooling coil it must be carried to the sewer.

The One-Pipe Loop system of installation gives the best results and should be used on all new work. (See Specifications.)

**Rates :—**

30 cents per square foot for direct radiation per season.
35 " " " " " indirect " " "
20 " " " " " Cooling Coil " "
Meter rate, 60 cents per thousand pounds of water.

A square foot of radiation is about three feet of one-inch steam pipe, and a charge is made for all piping which is not covered with an approved non-conducting covering, whether contained in radiators, coils or piping to radiators.

Indirect radiation is the placing of pipe in such manner that cold air is passed over it from any source to extract the heat, and is mostly used in dwellings, as it supplies a constant source of fresh, warm air, giving a superb plan of ventilation.

Cooling coil is necessary to extract the remaining heat from the water before discharging to the sewer, as without this device considerable waste of heat would occur.

*Payments*—The total contract amount for the heating season is divided into six equal payments, payable on November 1st, and the first day of December, January, February, March and April following. If contract amount is less than $25, one-half is payable November 1st and one-half February 1st following.

The above rates are made for the entire heating season, and no rebates will be allowed for failure to use steam during the time specified.

### D. F. McGEE

Before we compare the merits of the two systems of central-station heating, namely, exhaust-steam and hot-water, it would perhaps be well to devote a few moments to a few facts which we have found to be necessary to the financial success of a heating plant.

*First*—The investment must be kept as low as is consistent with good workmanship and first-class construction.

*Second*—The proposition should be to utilize the exhaust steam to the best advantage by installing only just sufficient mains and radiation to use up all the exhaust steam during time of maximum load.

The claim of certain promoters of heating systems, that there is money in live-steam heating, and that the electric light and power furnished need be considered only as a by-product, is untrue, and has resulted in the installation of heating plants that can not be run on a paying basis. Before installing any system, the manager should take into consideration which one will give his customer the best satisfaction; which will be reasonable in first cost, and, at the same time, be economical in operation. My experience with the various steam, hot-air and hot-water systems has convinced me that nothing meets the universal requirements for a central plant so well as hot-water heat. In fact, it is the only heating system in which regulation of temperature in the various buildings is absolutely under the control of the attendant at the central plant without a complicated system of thermostats; these thermostats increase the first cost of installation, are always getting out of order and are consequently a continuous source of expense.

In our plant we have posted near the thermometer in the main supply pipe a carefully tabulated schedule by which the engineer can tell at a glance how hot the water must be to warm the buildings to 70 degrees at any given outside temperature. As a result, our customers seldom touch a radiator valve during the entire season. The fact that the temperature of the heating surface in the entire system can be controlled is of particular advantage in moderate weather, for by controlling the temperature with a hot-water system a given amount of heat can be spread out thinner and will do more work than the same amount of heat will do with a steam system. The customers need not touch an air valve, consequently that disagreeable odor of cylinder oil, so much in evidence where exhaust steam is used direct for heating, is entirely eliminated, as well as all crackling and snapping of pipes, so familiar to us all where steam is used for heating buildings.

To make a plant successful every corner must be guarded, and frequently it is a number of small economies that determines whether or not the plant is profitable. To illustrate: In operating an exhaust-steam heating plant there occurs loss of power and useful work due to back pressure, and I will state, for the benefit of all who are familiar with or who have not given the matter sufficient thought, that back pressure must be deducted from the mean effective; and with an exhaust-steam heating plant, running as they do in some places with 20 to 25 pounds' back pressure, and with a boiler pressure of 100 pounds, there should be at quarter cut-off a mean effective of about 40 pounds. Twenty pounds of back pressure of course means that one-half of all the power is absolutely thrown away, and means duplicate investment in engines, or double the capacity of engines to carry the peak of the electric road.

The fact that a hot-water heating plant can be operated in connection with condensing engines is a great advantage. The exhaust heater can be placed between the engines and condenser. With 26 inches of vacuum you can get about 115 degrees on the circulating water, which will answer on chilly days. With 22 inches vacuum you can get about 140 degrees. With 19 inches vacuum you can get about 153 degrees. With 15 inches vacuum, about 168 degrees. Our records for the past winter show that for 85 per cent of the heating season our circulating water was below 165 degrees. Now, when you need hotter water and the vacuum drops to 15 inches, it pays to throw open the relief valve and run your engines non-condensing. This kind of scheme makes the most economical kind of an arrangement, as a large portion of the winter consists of mild weather, the average temperature of the heating season in Chicago being 35 degrees above zero, according to the United States weather reports. This means that a plant can be run condensing most of the season and still get the latent heat of the exhaust steam for heating purposes. I had charge of the installation of such a plant at Waterbury, Conn., in 1896. In this plant we also installed an economizer for heating the circulating water with waste flue gases, which we found to make a very desirable combination. As there was only about 20 or 30 degrees difference between the outgoing and incoming water in the economizer, we experienced no trouble whatever from flues "sweating" or leaky tubes from unequal expansion, which occurs when an economizer is used for heating feed water only; this one was used for that purpose during the summer months.

Another feature to which I should like to call your attention is that the feed-water heater actually consumes from 12 to 15 per cent of the exhaust steam in heating the feed water. In our plant the exhaust steam is all condensed in the exhaust heater and the condensation is saved for return to the boilers, and the 12 to 15 per cent of the exhaust steam is not required for heating this water for boilers. In all the steam-heating systems the condensation is all thrown away through traps and drains to the sewers. This means that we can sell from 12 to 15 per cent more heat to our customers from our hot-water plant than we could from a steam-heating plant.

Our plant was started up in October, 1899, and the first season we had about 14,000 square feet of radiation in service. This gave us a loss of eight degrees, from the time the water left the plant until it returned, when the thermometer was 10 below zero. Last year we increased our load to 29,000 square feet, and the difference during our coldest weather was 15 degrees, with a difference of 20 pounds' pressure between the supply and return mains at the plant. This year, with about 35,000 feet of radiation in service, we increased the speed of our pumps from 20 to 30 pounds between the supply and return mains. We found that it required just 20 horse-power to maintain this pressure with a drop of 15 degrees.

Our pipe system consists of a closed loop or circuit of five-inch pipe about three-fourths of a mile long, with three three-inch shunts, each about 1,000 feet, extending off the main line. In this circuit—and part of it is a centrifugal or fan type of pump—are an exhaust-steam heater and a live-steam or auxiliary heater. The exhaust steam from our engines first passes through an open feed-water heater and grease extractor, which heats feed water for our boilers and also removes the cylinder oil from the exhaust steam. It then passes through the exhaust heater for the heating system, where it gives up its heat to the circulating water, the surplus, if any, escaping to the atmosphere. As this exhaust heater is elevated above the water line in the open feed-water heater, the condensation from the exhaust steam flows to the feed-water gravity, to be pumped to boilers as feed water. This insures us distilled water for our boilers at a temperature of at least 205 degrees, and enables us to use our water over and over again, which makes a very material reduction in our water bill as compared with those we pay in the summer months.

There is an opening direct to the atmosphere from the exhaust heater at all times, so that it is impossible to put any back pressure on our engines, and indicator cards taken from engines show that we can condense every particle of our exhaust steam without using an ounce of back pressure.

The live-steam heater is elevated some distance above the boiler and is similar to the exhaust heater, only much smaller. Here, also, steam passes through tubes surrounded by the circulating water of the system. When live steam is required for heating, it is taken from the main steam pipe direct to this heater. The condensation from the live steam returns to the boilers by gravity at the temperature corresponding to the pressure. This means returning the water to the boiler at a temperature of over 300 degrees, instead of allowing it to flow to the sewer as is done in all steam plants.

Our house connections are merely shunts taken off the mains. The size of each house shunt depends upon the number of feet of radiation required in the house to be heated.

We have all learned that to make an electric plant pay we must avoid the slipshod methods of construction that were considered good enough a few years ago. It was then thought that any kind of an electric plant was a gold mine, and we should do well to profit by the sad experience of a great number of lighting plants that were thrown together with this expectation.

To place a heating plant on a paying basis, it is necessary to watch and take advantage of every point. Do not think you can dig a hole in the ground, lay in it several miles of pipe, throw a few fence boards around it, run a block here and a block there for every building, and expect to pay 100 per cent on the investment simply because some smooth fellow tells you that a heating plant is a gold mine. In the first place, all underground work must be done in the best possible manner, bearing in mind that the mains can not be covered too thoroughly with a non-conductive material. All pipes should be thoroughly tested and leaks repaired while they are yet uncovered, for every drop of water—in fact, every heat unit—represents money invested, and should be guarded accordingly. It pays to cover all cellar piping, such as mains and branches, with a non-conducting material at your own expense. I find that one-thirty-second inch asbestos paper, which comes in rolls of about 100 pounds, answers this purpose very well. We saw the roll up into blocks about six inches in length. This gives us long strips of paper six inches wide, which should be wound spirally around the pipe, first in one direction and next the reverse, until there are several thicknesses around the pipe. This is much cheaper and very nearly as effectual as sectional covering.

While we can not state accurately the amount of coal chargeable to heating service during the past season, yet we are able to estimate same very closely from our past records and find that it is about 600 tons, which costs $1.70 per ton or $1,020.

We have in actual service this season 35,000 square feet of radiation. This brings us an income of $5,250.

Now the question of extending our system comes up. Our customers who have the heat in their business houses want it in their homes, and we could double the amount of radiation in service by extending our mains, and our station apparatus was planned for this. Yet we have decided not to do so, for when we take into consideration the interest on the additional investment for street mains, and the fact that we should then be compelled to burn coal, make steam to heat our water, and probably require extra boilers, we fail to see where there is any money in the extra investment and expense. We find now that to make the investment very profitable it is important to have a day load for the engines. This perhaps can be done to the best advantage by furnishing electric current to customers for light and power at a rate which will make it an object to use it and still permit of selling it at a profit. This point is apt to be overlooked by many central-station men. The promoters of heating systems tell us that we can sell our electric current very low, because we shall be deriving an income from the sale of our exhaust steam for heating purposes; and then, in the next breath, they tell us that we can make a low rate for heating because we are utilizing our exhaust steam as a by-product. A few moments' reflection will convince any man that it is impossible to cut on both ends of this proposition and still come out ahead; and it is not necessary to do so if it is undertaken in the proper manner.

Our local conditions are similar to nine-tenths of the lighting plants in the country, and I find that it is not very difficult to work up a very fair day load, even in a small town that has blacksmith, machine shops, laundry, printing offices, dentists, grocers, butchers, restaurants, livery stables, and numerous others who could use small powers to advantage. Very many towns have one or two mills of considerable size, which can be secured as customers. City pumping, in towns where there is a stand-pipe or reservoir, is very attractive, for this work can usually be done when the load is smallest, which is the time when you may need the most exhaust steam for your heating purposes. In our case several industries located in town for the very reason that electric power was available at all hours at a reasonable rate.

When soliciting prospective customers it is just as well not to lay too much stress on cheapness, but rather to enlarge upon the fact that you will be able to furnish them much better and more convenient service than they can secure in any other way, as a motor can be located in the most convenient place, and will not be a source of annoyance by causing dirt, heat or noise, and the customer only pays for the actual power used.

It is also advisable to make some arrangement with a responsible company to handle its motors. You are then in a position to go to your customer and quote him a price for the motor installed complete. You are very much handicapped unless you do this, for you may tell your customer that you will furnish him with power at a rate which may be perfectly satisfactory to him. He will write to different parties for prices on motors, and then his trouble will begin, and it is ten to one that he will become disgusted and drop everything. By making arrangements with some manufacturer, you can install the motor for a sum that will cover the cost of motor and necessary labor and still give your customer a lower price than any respectable manufacturer will quote them ; and, furthermore, you will have the advantage of standardizing your motors, which permits you to change them in case of accidents ; and your repair men soon become familiar with the construction of the machines, which you will find prevents many accidents and facilitates repairs.

During the past two years we have installed 50 motors, ranging from .25 horse-power to 10 horse-power. This, with one 85-hp motor driving a flour mill 24 hours per day and one 45-hp motor doing city pumping, gives us an average load of 200 horse-power.

When we installed our heating plant we placed wooden boxes to cover junction valves and house connections. On account of the city of Red Oak paving its streets this year we decided to replace the wooden boxes with brick ones, and we uncovered practically all of our mains; we found them to be in excellent condition; in fact, it would be impossible to tell that they had ever been used, so we can foresee no reason why they will not be in just as good condition many years hence, as we used nothing but wrought-iron pipe for the entire installation.

CHAIRMAN HUNT: I am sure we are greatly pleased to have these practical papers, and if there are any comments upon them we shall be glad to hear from the members.

MR. PYLE (West Chester, Pa.): I ask Mr. McGee how he handles installations where he has steam heating to do where buildings are already piped for steam heating and he wants to take on that business; that is, how he handles that business with his system of hot-water heating.

MR. MCGEE: We can use steam radiators for hot water by tapping a small screw in the top of each section. This is used to let out the air when radiators are filled with water at the beginning of the season; after that it requires no attention.

In regard to piping, any two-pipe steam job can be made to convey hot water with very little change. It is absolutely necessary to have two connections to each radiator to obtain circulation.

MR. ODWINE (Springfield, Ill.): I ask Mr. McGee if he recommends the company's installing the radiation, or whether he has outside steam fitters to do this work.

MR. McGEE: We find that it is much more satisfactory to do the fitting ourselves. It is almost impossible to get the ordinary heating contractor to follow instructions; he usually has his own ideas, and we find it difficult to get him to make necessary changes when he is at fault. We have installed 95 per cent of our radiation, and wish we had done it all.

MR. ODWINE: Do you do it at cost or do you make a profit on it?

MR. McGEE: We cleared $2,000 on the work last year. We do not find it necessary to do the work without a profit.

The four papers which follow were read by title:

# ARE FREE LAMP RENEWALS DESIRABLE

J. ENGLISH

Fifteen years ago, after a careful consideration of this problem as it affected those companies that I was managing, and after some experimenting with the other method of charging for renewals, we adopted the plan of free renewals, and have found it beneficial and wise.

We found that when the customer paid for his renewals a large portion of them would burn the lamps until they were "black in the face;" that renewals would only be made by them, practically, when the lamps broke. This resulted in extremely poor lighting service. We could devise no way to induce the user to renew his lamps with even reasonable frequency as long as he had to pay anything for the lamp, but that he would let the lamps burn until they broke, and complain to us that our service was poor. It was very evident that we could not expect to render satisfactory service under such conditions, and unless our service was good other illuminants would take its place.

A short experience in renewing lamps demonstrated the fact that if we were to do this work advantageously some definite system should be employed. The necessities of such a system seem to be that:

*First*—Lamps should be renewed often enough to insure the lamps in service maintaining a given candle power during that service, or a limitation in fall of candle power.

*Second*—The renewals should be made in such a manner as to cause no annoyance to the user.

*Third*—Renewals should be made often enough to obviate, practically, the necessity for customers ever calling for new lamps to replace those burned out.

*Fourth*—The system adopted should be one that would effect the desired end in the most economical manner to the company.

Referring to the first requirements, we determined that a variation of two candles during the use of the lamp was as large as would furnish satisfactory service. Testing soon demonstrated the fact that with three-and-a-half watt lamps we could not get an average burning of over four hundred hours and keep the lamp within the above limits. In the early days we did not in practice obtain such good results, but with the gradual improvement in the lamp we have reached a point where each and every lamp we put out can be relied upon to maintain its light within the limit. Starting at sixteen-candle-power they will all be at least fourteen-candle-power after four hundred hours' burning.

We therefore adopted a principle that all lamps on our circuits should be changed once in four hundred hours. It was quite clear that with a widely varying character of service if we changed uniformly all lamps at a given date we should remove many that had burned but a few hours and were good for many hours longer. It was equally plain that we could not assort these lamps in the places of installation, but we could bring all of them in to the station and then sort them by a photometer, discarding all lamps that were not sixteen-candle-power and putting in stock, to go out again, all that were sixteen-candle-power. This method we have followed in our different stations for over seven years. We change every lamp on our mains four times per year, usually in February, May, August and November. We find that this results in very few lamps having been used over four hundred hours. We find that forty per cent of the lamps we have changed and brought in are sixteen-candle-power, and all right to go out again.

The results of this method have been fine, and the experience of ten years has demonstrated:

*First*—That all our lamps while in service are at least fourteen-candle-power, or not at any time during their service more than two candles below the initial candle power.

*Second*—That this method delights the users, who feel they are really getting something for nothing. That we no longer have occasion to send out lamps between periods of changes, and rarely hear of a broken lamp.

*Third*—That the cost to the company of this method is at least no greater than that of the ordinary method of making free renewals.

*Fourth*—That the general effect on our business has been remarkably satisfactory; that our lighting is good, better than any I have ever had occasion to examine.

*Fifth*—That we have now passed beyond the point of complaints of service, so much so that we rarely see or hear from a user, unless it be on the question of rates.

Generally, therefore, I have not the slightest hesitation in saying that in my opinion no electric lighting company can afford to do business in the old ways, and that the sooner lighting companies recognize the inherent weakness of the incandescent lamp itself, and devote their energies to attempting to obviate the ill effects of this fault on the business, the more successful they will be.

## F. ELLWOOD SMITH

I used to believe that a lighting company, whether it were a gas company or an electric light company, should own nothing whatever inside of a customer's building except the meter; that the customer should provide all the necessary shut-offs, pipes or wires, the fixtures, and the gas burners or the electric lamps. The business of a gas company being to furnish gas and that of an electric company being to furnish electricity, I claimed that the company's responsibility ceased when it had delivered the goods of proper quality and quantity at the meter. Theoretically, this may be true, but practically it is not the best method. If customers use arc lamps it is almost necessary that the company furnish and care for the lamps, and I think that all electric light managers are agreed on this point. In the matter of furnishing incandescent lamps, however, there is a difference of opinion, and incandescent lamps are furnished on a number of plans.

In my own experience, for a number of years I required my customers to buy all their lamps; either from our company at cost, or elsewhere if they saw fit. They usually saw fit to buy elsewhere, getting an inferior lamp for less money, or not buying at all, and thus not using the electricity. To the average customer all incandescent lamps are alike, except that some are marked sixteen-candle-power and others twenty-four-candle-power, eight-candle-power, etc. The customers know and care nothing about voltage and efficiency. I have found lamps used on our circuits consuming five watts per candle power, and the customer thought he was getting a bargain when he bought this lamp for fifteen cents instead of paying us twenty cents for one of our lamps, which would consume only. 3.1 watts per candle power. Many a time I have found 110-volt lamps on our 104-volt circuit and customers finding fault with us because they did not get a good light. When customers have to pay for new lamps they will use the old lamps just as long as they will burn; and if one lamp does not give light enough, two must be used, and then the bill is large and the customer has a double kick coming to the company: the light is dim and the bill is large. Under such conditions the frequent result is a notice to the company to discontinue the service.

Several years ago I retained a number of customers that were dissatisfied, by simply giving them a few new lamps and proving to them that the trouble was in the lamp and not with the current. The results were so satisfactory in such cases that I was obliged to become converted to the free-renewal belief and to give my customers a new lamp for every old lamp returned. It is impossible to educate customers so that they will buy good lamps when needed, and, therefore, in order to give good service the company must take the matter into its own hands and give free renewals.

The cost of the lamps is a necessary expense, just as much so as is fuel. A customer using a dim lamp of, say, twelve-candle-power, is paying for, say, thirty-seven watts. You give him a new lamp giving sixteen-candle-power and consuming, say, fifty watts, and he will be satisfied with the light and willing to pay for the additional current. You will very soon get back the cost of the lamp and get an increased revenue and a satisfied customer. I urge our customers to change their lamps often, and if a lamp is dim to remove it. This request is printed on every monthly bill. We do not give new lamps in exchange for broken lamps, and exchange free only eight-candle-power, sixteen-candle-power and twenty-four-candle-power lamps. We sell new lamps of these candle-powers to our customers at ten cents each. We will get for our customers any other style of lamp and charge them the actual cost to us.

I have not adopted the method of sending men to the customer's house and replacing his lamps, but I try to keep the dim lamps weeded out by circulars and notices on the monthly bills. This plan works fairly well, and I do not often have complaint of dim lights. I confess, however, to believing that a periodical systematic renewal of all lamps on the circuits is a very good thing.

All lamps returned are photometered, and if of sufficient candle power are put into stock to be used again. We retain those giving fourteen-candle-power, and use them near the centre of distribution, where the voltage is a little greater.

I do not believe in furnishing free the first installation of lamps, especially in residences, because in a great many instances the return per lamp will be very small, and I believe that the cost of the first lamps will not keep away any desirable customers. I believe that every company furnishing electric current for incandescent lighting ought, for its own good, to furnish free incandescent lamp renewals.

## F. W. LITTLE

The question of free lamp renewals has been but lately considered by the Peoria Gas and Electric Company, and we have had no opportunity to observe the results of such a policy in this community. The supply business of this city has been carried on entirely by the local supply companies, under a general understanding that we would not interfere in their territory further than selling incandescent lamps at practically cost.

Our rates for electric current are very low, being limited by the terms of the ordinance under which we are working to ten cents per kilowatt hour as a maximum.

During the last three years we have entirely remodeled our generating plant and distributing system, entailing a large expense, and requiring a change of voltage of our secondaries from 52 to 104 volts, thus necessitating a change in consumers' lamps. This was done by an exchange on the basis of a charge of twenty cents for each new 104-volt lamp and an allowance of ten cents for each 52-volt lamp replaced. This resulted in bringing up the incandescent lamps on our system to a very good standard at a low cost to the consumer.

The above conditions have delayed our making any reduction in the selling price of lamps. We are now, however, considering selling lamps at cost and renewals at a nominal price where consumers turn in burned-out lamps of the brand we handle. We believe this will insure the use of first-class lamps on our circuits and the freer use of current, due to the low cost of the lamps, without entirely cutting off the revenue from lamp sales. If results indicate that the step is unprofitable, the loss will not be as serious as if we furnished free renewals; while if results indicate that a further reduction in the price of lamps would be advantageous, we are in favorable position to make it. The renewal of lamps at a low cost, or free of cost, to the consumer must be considered largely as an advertisement and a talking point in favor of the use of electric current in preference to other forms of light. But where established rates for current are such that concessions must be carefully counted before being allowed, we think it good policy to make each concession count for as much as possible.

## W. J. GREENE

From 1888 to 1893, free lamp renewals were furnished by us. In 1892 it became evident that the net earnings were not keeping proper pace with the growth of the plant and the increased investment. In 1893 this condition became critical, and a change of some kind became imperative. Two reforms were instituted: one, the adoption of a minimum charge proportional to the maximum-burning lamps; the other, the discontinuance of free lamp renewals. The desired results followed. These changes were soon followed by the adoption of a two-rate system in connection with the minimum charge, so that consumers upon whom fell the heavier cost of lamp renewals were many times compensated for such expense by the lower cost of service.

The reasons originally advanced in favor of charging for lamp renewals were:

*First*—Reduction in operating expenses.

*Second*—Consumers had been accustomed to maintaining equipments in all other methods of lighting, except arc lamps, and this company considered lamp renewals a legitimate expense to be borne by consumers. Nearly all of our customers concurred in this view.

The reasons for continuing present arrangements until such time as local conditions may make desirable the furnishing of free lamp renewals, are:

*First*—The rapid increase of business, in the face of hard competition with gas, being difficult to provide for with increased capacity, owing to manufacturing delays and engineering difficulties,—makes any check to growth, as may result from charging for lamp renewals, desirable.

*Second*—Lack of facilities, under present office arrangements, to carry a supply of lamps and conveniently serve consumers with lamps from the office. Lamps, supplies and construction work are furnished by local supply houses, who are, on the whole, furnishing consumers with a good lamp at figures slightly in advance of cost.

*Third*—Advantages accruing to supply houses from handling lamps and the better service they can render us in return.

*Fourth*—Avoidance of the extra time required on the part of the management, and extra cost of rental for storage room, labor and lamps.

## FRANCIS W. WILLCOX

Electric lighting has been largely built up on gas practice, and the custom of making the consumer supply his own lamps, where it exists to-day, is a direct inheritance from the practice followed in gas lighting of having the burners supplied by the consumer.

With the old simple tip burner it made little difference in gas lighting, since the burner was a simple mechanical device, which if kept clean would not deteriorate, and could, therefore, be used indefinitely. It made no practical difference, therefore, whether the consumer supplied them or not. The quality of the gas and not the burner determined the character of lighting service.

With incandescent lamps the case is quite different, the lamp being a complicated device in its operative results, requiring technical knowledge to select the best type and proper efficiency. It also steadily deteriorates in service, requiring replacement at fixed periods to maintain lighting results. In other words, we have here a case in which the burner (*i. e.*, the lamp) is a feature having a large influence on results.

With the introduction of Welsbach lamps in gas lighting we have a burner quite similar in character and in results to the incandescent lamp. It would be natural to expect, therefore, that the same necessities that have caused so many electric-lighting companies to provide for the supply of the lamps to their consumers, would cause gas companies to take up the supply and maintenance of Welsbach mantles.

In point of fact we find this very practice becoming adopted by gas companies, as can be seen from the subjoined accounts. The arguments and reasons given for the step are exactly similar to those found and advanced for free electric-lamp renewals, proven and established by practical experience with the Welsbach lamp in service. The result is, I think, quite positive and conclusive testimony in favor of free lamp renewals for electric-lighting companies. There is this difference to be noted between Welsbach mantles and incandescent lamps. The Welsbach mantle is a delicate device and may be readily broken with no evidence to show whether it failed of its own accord or was deliberately broken. It would, therefore, seem necessary to make some nominal charge for renewals to prevent fraud on the part of the consumer. This necessity does not exist with incandescent lamps, which can be readily broken only by destruction of bulb, thus giving evidence of forcible or deliberate breakage. Free electric-lamp renewals are, therefore, wholly practical as not liable to cause any loss from fraud.

# WHAT IMPROVEMENT IS DESIRED IN METERS

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### ROBERT FERRIS

Considering the improvements in meters during the last few years, it may be reasonable to expect still further improvements along this line. Perhaps the greatest improvement would be that which would eliminate the possibility of a meter's being stopped when it should be in motion. The success of a meter depends largely upon the friction of all moving parts being reduced to a minimum. Anything that would replace to advantage the pivot and jewel, without sacrifice, would be an improvement; for if we can keep a meter in motion, it should be easy enough to keep it in calibration.

The efficiency of meters is something of importance, yet a meter should have plenty of torque. While it is possible to save considerable by having efficient meters, it is also possible to lose considerably, more by having meters that will not stand up on light loads.

Durability, then, is another consideration, which with reference to meters means that a meter can be put in service and remain there without additional cost, whether in the shape of attention, repairs, or loss of revenue.

Credit should be given the engineering forces of the manufacturers of meters, for they have given us what we have. They may be accused of developing the idea of some fellow who in an unguarded moment let some salesman "in on it," but even at that they should have credit for the development. If any of us have ideas that lean toward improvements, we should be willing to see them developed if we can find anyone that will spend his money to do it.

It is rather hard to say just what improvement is most desired in meters, for we find ourselves pitted against the engineering forces of all the manufacturers, and it is known that there are many who are trying to make a living trying to produce that improvement. A few suggestions might be made that would at least furnish something for the engineers to work on, and after submitting mine I should be glad if I could know that I was forgiven. They are: A universal meter in size and style; a backboard for meters, of a standard pattern, which could be adapted to meters of any make on the market; a registering dial that would read directly in dollars and cents, or if not that, then the adoption as a standard of direct-reading dials and a simple tell-tale hand on clock for calibrating purposes; a meter that would take the place of the combination of watt and discount meters, having the effect of registering at different rates of speed, which would be governed by the load that was passing. To illustrate: If we had, say, a 100-volt wattmeter of 25-ampere capacity, instead of showing a straight line from five per cent of its capacity to full load, the meter speed would represent at full load accurate registering, and as the load dropped the proportional rate of registering would be a certain per cent slow or fast.

If it were wanted to increase the hours of lighting on a twenty-four-hour service, the first method would apply; and in the stations where only night service is given and it is wanted to increase the quantity of lighting for short hours, the latter would apply. Of course the reading would not show the actual watt hours consumed, but that need not be a serious objection. The reading could be called units and the price would be so much per unit, and instead of discounting bills, we should find that the meter had already taken care of that.

## CLIFFORD A. WHITE

From a commercial point of view, the following considerations regarding electric meters appeal to me in my capacity as cashier of an electric company:

The electric-lighting business is full of mysteries to the general public with whom it has to deal, and, consequently, anything not easily understood arouses suspicion immediately. Therefore, anything that concerns the public should be as simple as possible.

The meter dial should read direct in kilowatt hours, thereby eliminating the use of the constant and the use of two terms, kilowatt hour and watt hour; there should also be a hand on the dial for testing purposes.

The term kilowatt hour is not easily explained understandingly, but as this is the most appropriate and generally accepted unit of electrical energy it would be highly impracticable to adopt any other term, and the public must be educated to its meaning.

Nearly all meters now in use register in watt hours, thus making necessary the use of two terms, which is confusing to the uninitiated. The average price for current is twenty cents per kilowatt hour, which will continually grow less rather than more; therefore the kilowatt hour should be the unit to use, as by adopting the rule of reading in every case the figures the hand has passed on the unit dial, the error in reading would never amount to more than ten cents to the customer, and the total sales of the company would not be affected at all. The new meters now being placed on the market register in watt hours, which is a great improvement over those that required the use of a constant; but a direct-reading dial should be designed to replace those now in service having constants. This does not seem a mechanical impossibility, and if the cost were reasonable it would be generally adopted. The constant has always been a perpetual source of annoyance and error. Its use makes a great deal more work in the bookkeeping department, and complicates the rendering of bills correctly, consequently creating a continual and unnecessary expense in the office. It is next to impossible to make the average customer understand its meaning, and it should be returned to the laboratory whence it originated, never to be resurrected.

Testing should be done at the dial rather than at the disk; for while the chance for error between these two points is slight, by making the test at the dial that chance is reduced to a minimum.

The business is every year becoming more complicated, and any suggestions that tend to simplify matters should receive the attention of station managers and manufacturers alike, especially those that directly concern the public, for the simpler and more easily understood such matters are, the better satisfied the public is, and satisfaction brings more business.

### H. H. SCOTT

The present inductor-type meter is fairly satisfactory, but is susceptible of improvements. The meter should be as light as possible, and, apparently, the lighter the moving parts, the more durable the jewel. Constants should be eliminated; the dials should be enlarged and placed nearly flush with the front of the meter. The meter should read directly in kw-hours, for the dial indicating fractions of a kw-hour is of no benefit and only adds a factor for error.

The maximum capacity of a meter depends to a very large extent upon its ability to dissipate heat. Therefore the resistance of the series coil should be made as low as possible, taking into consideration, however, the bulk and weight of meter. Central stations want a meter of uniform rated size for residence lighting, which will take care of any ordinary installation. To do this, the meter must be able to withstand a very considerable overload for at least a short time; must register this overload without any appreciable error, and still maintain its accuracy on the starting loads.

The total resistance loss in the shunt and series coils represents the heat by multiplying watts lost by 3.41, the product equaling the heat in B. T. W's.

The loss in the shunt coil is constant, 24 hours in a day, 365 days in a year, and therefore every watt thus lost represents a yearly loss of 8.8 kw-hours. The drop in the series coil affects our regulation, and this is another reason why minimum loss is desirable. In this connection, if you will take the trouble to test any or all of our well-known meters for accuracy on overloads to the point of a breakdown, the results may be of much interest. Such a test will probably show you that some meters are accurate as high as 500 per cent rated capacity, and the shellac will not vaporize until 700 per cent is reached, while others will burn at 300 per cent or less.

Many stations are gradually changing from 125 or 133 cycles to a lower frequency, possibly changing ampere-hour-meters to wattmeters at the same time. The performance of a meter running on the higher frequency while adjusted for the lower, will probably show that it might have been well, after all, to have left the old meters in service until the change of frequencies had been completely effected.

Meters should be so made that their adjustment for accuracy on starting and inductive loads is a comparatively easy matter. We want an accurate meter on light loads. Therefore an easy adjustment for such loads and an adjustment for creeping are essential. Manufacturers should take especial care in the selection of the permanent magnets, for undoubtedly much of our trouble with old-type meters is due to the aging of the magnets.

The tendency of the designers of several well-known meters is toward a higher speed at rated load. The moving parts have been made lighter, but, notwithstanding this, will not this higher speed necessitate our more frequent inspection of the jewels or bearings?

# LIQUID FUEL

### JAMES W. WARREN

The chemical composition of liquid fuel and its calorific value as compared with that of solid fuels, have been so ably presented in various papers that it is hard to find an opening to introduce new matter on this very interesting subject.

The State of California, while prolific in natural resources for the support and comfort of mankind, is a little shy on coal; but, though lacking the solid carbon, we are blessed with an increasing volume of hydrocarbon, and the daily uncovering of new oil-producing fields in Southern California assures the steam user of an abundant supply of liquid fuel. Not alone on *terra firma* is the rhythmic bump of the oil-well drill heard, but on the bosom of the Pacific the drill goes down into the bed of the old ocean, and, tapping the oil strata, we draw from under the mighty deep millions of gallons of liquid fuel.

The discovery of liquid fuel in such large quantities in Southern California has made its use general for all manufacturing purposes, also for the burning of brick, oiling roads to subdue the dust, for smudge fires to temper Jack Frost, for malt houses, for all steam railroads in Southern California, and for crematories.

The petroleum oils of Southern California are of an asphaltum base and carry with them about thirty per cent of asphalt. There being little paraffin and a comparatively small amount of illuminating oil in their composition, distillation is not as general as with eastern petroleums. The greater amount of distillation of the local petroleum is for the large quantities of asphalt it carries, this asphaltum finding a ready market here and in the eastern states.

The liquid fuel from our local oil fields is pumped from wells within the city limits. These wells average 1,000 feet in depth. The oil carries in suspension considerable sand and water, for the removal of which storage and heating are required. This oil is delivered to consumers in tank wagons of about twenty-barrel capacity. When the oil is delivered to the consumer a sample is taken from the wagon and tested for temperature, gravity and percentage of water. The average temperature is 70° Fahrenheit, the average gravity 15° Beaume, and the percentage of water averages about six per cent of the load in the wagon. The method of determining the amount of water in the oil is by the gasoline test. This test is made with a test-tube holding 100 cubic centimeters and graduated in one-hundredths. The tube is filled with fifty cubic centimeters of the oil test and fifty cubic centimeters of gasoline. By agitating the mixture thoroughly the gasoline cuts the envelope of oil that surrounds the globules of water in the oil, allowing the water to precipitate itself to the bottom of the tube. The percentage of water that gathers in the bottom of the tube determines the percentage of water in the load, and deductions are made accordingly.

The low gravity and high flash test of the local oil make it perfectly safe for use under boilers and in storage. Loss by evaporation due to exposure to the heat of the sun is comparatively small.

The method of handling the liquid fuel at the generating station of The Los Angeles Electric Company is as follows: The fuel is pumped from the main storage tank to the furnace supply tank of 100-barrel capacity. In this tank the oil is heated to 80° Fahrenheit. It then passes to a pair of small duplex steam pumps which give it twenty pounds gauge pressure. The oil then traverses pipes within the breeching of the boilers, which heats it to 190° Fahrenheit, then on to the burners. The burner is of the spray type, using steam as the medium of spraying the oil. These burners consist of two circular disks, one and one-half inches in diameter, slotted, and arranged in such manner that the oil, fed by separate pipe to the lip of the upper disk, meets the steam at its orifice just under this lip. This steam forms a fantail spray which breaks up the oil into particles sufficiently small to ignite immediately by the heat of the brick lining of the furnace and the layer of bricks upon the grate bars. Each one of these burners has an evaporation efficiency of 3,000 barrels of water per hour from and at 190° Fahrenheit. The sound of combustion produced by these burners is comparatively soft. The flame fills the furnace-box, covering the entire furnace-box sheets of the boiler. This gives active heat action to all of the evaporative service of the fire sheets without unduly heating any one particular portion, and, at the same time, perfect combustion is taking place, as denoted by the absence of any colored gases leaving the stack.

If economy in the use of liquid fuel is to be considered, a high-temperature thermometer in the smoke stack is as necessary as a water-gauge glass on a boiler, for by the thermometer only can the fireman graduate the amount of air necessary for perfect combustion. As a test of this, our fireman can raise the temperature of the gases in the stack from 450° to

600° Fahrenheit by closing the ash-pit doors one inch. By the use of the thermometer the fireman can so regulate the burners under each boiler that it will do its proportionate amount of work. This is very essential in plants working many boilers set in batteries. It is an important point that the evaporative efficiency of the burners should be kept as high as possible; that is, the burner that consumes five per cent of the steam which it evaporates, should not be allowed to consume twenty per cent, which it might do if not judiciously controlled.

In summing up the advantages of liquid over solid fuel for steam-generating plants, we obtain the following:

Concentrated form,
Economy of handling,
Increased evaporative efficiency,
Cleanliness,
Abatement of smoke nuisance,
Reduction in depreciation account
Reduction in repair account,
Reduction in sundries account,
Efficiency in. emergency.

In considering the comparative storage area required for coal and for the equivalent amount of oil, taking yard storage as a basis, forty per cent less area is required where oil is used. In the floor area of the fire room fifty per cent less floor area in front of the boilers is required when oil is used as a fuel. In economy of handling, the complement of boiler-room help is reduced fully fifty per cent and the transportation of ashes is entirely eliminated.

The evaporative efficiency of oil as compared with the same weight of our average good steam coal, is twenty-eight per cent higher than that of the coal.

In making a comparison of the cleanliness in the use of oil as against coal, and the saving gained, the advantages are so far-reaching in the minor items that only a few of the larger savings will be touched upon. There is a saving of seventy-five per cent. in the cost of paint, waste, brooms, tube cleaners, etc., required in the everlasting removal of coal dust, dust from ashes, soot, etc.

The use of liquid fuel solves the smoke problem, as smoke issuing from a stack where oil is used for fuel is an evidence of improper combustion, and can be avoided.

The use of liquid fuel reduces the deterioration of steam-generating apparatus twenty-five per cent. This is effected by the even fire of fuel oil, there being no undue strains on the fire sheets, caused by the frequent opening and closing of fire doors, as in the use of coal. The absence of large amounts of sulphur in oil prevents those chemical combinations which so rapidly corrode the tube ends. Ashes, lodging in obscure places and inaccessible corners of the boiler, absorb moisture and form a strong chemical affinity for the parts of sheets with which they come in contact, causing rapid corrosion.

As to the reduction in repair account, the cost of renewing the lining of furnaces, renewing grate bars, bridge walls, back arches, etc., is reduced eighty per cent by the use of liquid fuel.

In the reduction of the sundries account, the items of coal scoops, slice bars, hoes, firing irons, tube scrapers, wheel-barrows, water hose, steel brooms, wood for starting fires, etc., are entirely wiped out when liquid fuel is used.

In the use of liquid fuel the engineer has an able assistant to help him out in case of an emergency call upon his boilers. If required to raise steam rapidly he can do so without endangering the burning out of his boilers as greatly as when coal is used. On the other hand, if for any reason it is necessary to shut the fires off immediately, it can be done without the annoyance and danger of pulling out a heavy fire from the furnace.

In conclusion: The record of results obtained from the use of liquid fuel in Southern California stands out so prominently in favor of liquid fuel that many of the larger steam-generating plants in the northern part of this state have abandoned the use of coal in favor of liquid fuel. Its simplicity in operation and control, and the low cost of installation, make it a desirable factor in the economies of a steam plant.

## H. T. EDGAR

The use of oil under boilers is by no means a novelty, but a practical every-day experience with many of us. No doubt a great many members are quite familiar with burning fuel oil, and the information contained in this paper will not be new to them; but to those of you who are not familiar with the subject a few facts may be of interest.

To the people of Texas the fuel oil question is one of vital importance, and will undoubtedly do more to increase her manufacturing interests than any other one industry within her borders. To those of us who have been compelled to burn bituminous coal costing from five to six dollars a ton, the discovery of fuel oil in the Beaumont oil fields came as a welcome relief, as its use as a fuel has relieved us of those excessive manufacturing costs that were a constant drain on our resources. There is undoubtedly in existence a great deal of data on the subject of burning oil, as very extensive experiments have been made, but this paper is only intended to treat of the subject in a general way.

Fuel oil was first discovered in Lima, Ohio, in 1885, by Mr. Ben Frotte, who was boring a well, hoping to obtain water but finding oil instead. It has been discovered in many parts of the United States and Canada since that time, but its use under boilers at Lima is supposed to have been the first application of oil as fuel. There are large oil wells in Pennsylvania, Ohio, and most of the western states, particularly in California. In most of these places crude oil is not used as a fuel, but is refined and the by-products used for burning. The oil is discovered at different depths in different parts of the country, and varies from ninety to two thousand feet.

Fuel oil was discovered at Beaumont in January, 1901, and up to the present time there are about 220 six-inch and eight-inch wells, most of them being from one thousand to one thousand and fifty feet in depth. A great many of these wells are gushers, but it is only a question of time when the oil has to be pumped, and all of the wells will sooner or later become pumping propositions.

There is a great deal to be written in regard to the burning of fuel oil. Its economy depends entirely upon the style of the boiler and the manner in which it is handled. In some places fuel oil is burned, not because it is cheaper than coal, but because it has a great many advantages over coal. We find in the use of fuel oil that it increases the capacity of the boilers slightly and the capacity of the chimney about thirty per cent. In addition to this, it decreases the costs in the fire room. It is necessary to employ, however, in the fire room high-class labor, and our experience has been that the man in charge must be competent and fully up to the standard of a first-class fireman, for while there is not much hard work to be done the entire apparatus requires constant and intelligent care.

The high price of coal has been the means of inducing all steam users to investigate the question of fuel oil, and it is being put in use very rapidly. During the seasons of 1901 and 1902 about three per cent of the industries of Texas were burning fuel oil, and the calculations are that during the seasons of 1902 and 1903 about thirty per cent of the industries will be using it.

There has been considerable anxiety felt as to the effect of fuel oil on the boilers and stack. The following is taken from a letter from the Chief Inspector of the Hartford Steam Boiler Inspection and Insurance Company of New Orleans, addressed to Mr. H. F. MacGregor, President of the Southwestern Gas, Electric and Street Railway Association, dated April 17th, and refers to the experience of that company with fuel oil:

"At the outset our inspectors received special instructions concerning the new fuel, and were cautioned to use special vigilance to the end that its effects on the boilers under our charge might be ascertained as quickly as possible. Thus far the closest scrutiny has failed to reveal any deleterious effects where proper care was exercised in installing the oil-burning apparatus and in its operation afterwards. Some apprehension was felt at first that the amount of sulphur contained in the crude oil might be sufficient to cause more rapid deterioration from pitting and corrosion than had been experienced with coal. This fear has thus far proved groundless, no extraordinary pitting of tubes and shells having been noted since the introduction of oil as fuel. This may be accounted for by the fact that the amount of sulphur liberated per thousand heat units is less with oil than with coal.

"The wear and tear upon the boiler structure is probably less with oil than with coal. Much of this wear and tear with coal is due to strains produced by the sudden and frequent inrushes of air against the hot plates and heads while furnace doors are opened for firing, resulting often in leakage at seams and tube ends and small fractures of the boiler plates. These are almost entirely avoided by using oil for fuel. The doors are never opened and the temperature remaining practically even, there are no injurious contractions."

The method of burning fuel oil, the changes necessary in the boilers, the style of burners, etc., are practically the same in all cases, but a brief description of the installation in the electric-light plant at El Paso, Texas, may be of some interest.

## STORAGE

The oil is stored in two steel tanks, each 30 feet long by 10 feet in diameter, made of 3/16-inch steel, which are buried in the ground directly behind the plant. These tanks are buried end to end, four feet below the surface, and covered with a four-inch wood lagging treated with a wood preserver to prevent the alkali in the soil from destroying the tanks. Between the ends of the tanks is a manhole four feet wide by eight feet long, into which all pipes, valves, and connections possible are made, affording easy access to make repairs. The tanks are connected together with both the supply and suction pipes and are filled and emptied both at the same time, but the piping is so arranged that it is possible to use each tank separately, affording an opportunity to clean either of them. The oil is delivered in specially-built tank cars, holding from 155 to 300 barrels of oil. A rubber hose three inches in diameter is used to convey the oil from the tank cars to the tanks, and gauges arranged on the back of the plant show the amount of oil in each tank. It takes about forty minutes to unload a car of 6,500 gallons. Each of our tanks will hold about 17,000 gallons, and under the present conditions of operation this will last about half a month, affording us a fair storage capacity.

## PUMPS

There are two 3 × 2 × 3 duplex steam pumps mounted on an iron frame standing about three feet six inches high. These pumps draw the oil from the storage tanks through a one and a half-inch iron pipe, and discharge it through a one-inch pipe into a small chamber about 14 inches in diameter by two feet six inches long, placed between and slightly above the pumps. The oil enters this chamber at one end, passing through a partition of very fine wire gauze into the other end of the chamber, where it comes in contact with a heating coil heated with the exhaust steam from the pumps. This runs the temperature of the oil to about 145 degrees Fahrenheit, being the proper temperature at which the oil atomizes freely. The gauze screen or partition is used to strain the oil and keep back sand and dirt, which, if allowed to pass to the burners, would in time stop up the small openings through which the oil passes. The pump being a double one gives us a reserve in case of accident.

### BURNERS

Experiments have been made with two burners, one known as a straight-blow burner and the other known as the cross-blow burner. Thus far we have been unable to see that one burner has any special advantages over the other as regards economy or ease of manipulation. In the straight-blow burner there is a central brass casting with a small bore through which the oil passes. The outside of this casting is fluted like the rifling of a cannon, and outside of this is another brass tube. The steam passing through this space and the fluting, gives it a whirling motion, so that as the oil flows out of the inner bore it is caught by the whirling steam and atomized. It is considerable work to set this burner in place, as there are many changes to make in the brick work of the furnace. In order to atomize the oil thoroughly, the bridge wall of the furnace has to be reconstructed and a sort of grill work of fire brick put in its place. The grate bars are lowered about one foot in the fire box, and a double row of fire brick laid on top in such a manner as to form an air chamber between them through which all air must pass in order to reach the furnace, the idea being that the air becomes heated before coming in contact with the fire. There are two of these burners under each boiler, each one being set in the fire door, and the door bricked up solid, except a small hole for looking into the furnace. When once set up it is rather difficult and expensive to change back to coal.

The cross-blow burner is constructed somewhat differently from the straight-blow burner. It consists of a small casting with an overhanging top perforated with small holes arranged in a semi-circle on the under side. Just below these holes is a slot in the burner through which the steam issues in a sheet, and the oil being forced through these holes comes in contact with the steam and is atomized. This burner is put through a hole between the fire doors, using only one burner to a boiler. The grate bars are left in the same position as when coal is used, and are covered with a layer of fire brick laid in mortar. These bricks cover the entire grate except a few inches in front for air, and the bridge wall is left as used for coal. The furnace doors remain unchanged. The principle of an oil burner is that the steam comes in contact with the oil and atomizes and separates it as widely as possible.

To convert a furnace from coal to oil will take from two to three days, and to convert to coal again from two to three minutes, where the cross-blow burners are used. After being once equipped for oil, however, and then converted to coal, it could be reconverted to oil again in about one hour.

In the use of fuel oil it is necessary, in order to get economical burning, to have the oil flow to the burners at a steady pressure. Our first experiments demonstrated the necessity of this, as our fires were often put out through unsteady pressure. With a steady pressure of steam at the burners, if the oil pressure decreases, the steam is likely to blow out the fire, while if it increases, more oil comes through the burners than could be properly atomized, the result being, 1st: The fire smokes badly. 2d: The excess oil runs away in the ash pit, causing liability to explode. 3d: It fills the tubes with a soot that is much harder to remove than coal soot. 4th: The oil that is not atomized, and flows away, is lost.

In order to insure a steady pressure of oil it is necessary to provide an auxiliary air chamber. Connected to this air chamber is a small safety valve which, in case the pressure runs above the point required, returns the excess oil to the storage tanks.

To start the burners it is simply necessary to turn on the steam and a small supply of oil, and throw a piece of burning waste into the fire box, and we immediately have a full fire. To regulate it properly it is necessary to adjust the supply of both steam and oil until the fire burns without any smoke; and if properly regulated we get a complete combustion of the oil and avoid almost entirely the presence of soot in the tubes and smoke from the stack. It is also possible, by simply increasing the supply of both steam and oil, to force the boiler to any extent. Care must be taken, however, in selecting burners to get one that thoroughly atomizes and distributes the oil so as not to confine the fire to any one part of the shell and burn the boiler.

The boilers are provided with peep holes in the back to enable the fireman to see the condition of his fire. Care must be taken to watch the fires very closely, and in case they go out for any reason to shut off the oil immediately, as the gas from the oil, combined with the air in certain proportions, is very explosive. Cases of this kind have been known where an explosion has occurred which took the damper up the chimney and blew out the front of the boiler.

The statement has been made that it takes about four per cent of the steam generated to operate the oil apparatus. We have made no experiments to demonstrate the accuracy of this figure, but our observations go to show that this percentage is large.

In a small plant like this, which is subject at times to a total shut-down, in case the steam of all boilers goes down, it is impossible to start the fire, in which case an auxiliary steam generator must be employed, or the fire brick be removed from the grates and coal be used to get up steam.

In installing this apparatus it is necessary to comply with certain rules and regulations of the insurance companies in order to prevent an increase in insurance rates. These rules, however, are not in any way unreasonable, but are necessary to afford ample protection to the plant. Their principal requirements are:

1st—That the storage tanks shall be buried four feet under the ground and ten feet from the building; or, if located more than one hundred feet from the building, may be put above the ground or only partially buried, in which case they must be surrounded by a brick or earth embankment forming a reservoir of sufficient capacity to hold double the contents of the tank.

2d—They must have a gas-tight manhead at the top.

3d—They must not be filled in excess of ninety-eight per cent of their capacity.

4th—They must have a two-inch vent pipe.

5th—The highest point in storage supply must be at least two feet below the level of the furnace where oil is to be burned, thereby preventing gravity feed to the boilers.

What the saving has been per horse-power or kilowatt hour as compared with the use of coal, it is impossible for us to tell, as prior to the present ownership of this plant, which changed hands last fall, no records had ever been kept of the kilowatt output or the tons of coal used per month, so that comparisons are impossible to obtain. There is no question, however, but that there is a very large saving in the use of fuel oil. It is claimed by the advocates of fuel oil that four barrels of oil, forty-two gallons to a barrel, are equal to one ton of good bituminous coal.

Experiments have been made by the Water Works Company at El Paso, and some very accurate figures have been obtained. The results of these tests show that the cost of burning fuel oil is exactly half the cost of burning coal, the coal costing $5.00 per ton, and fuel oil costing 70 cents per barrel. The coal used prior to the installation of fuel oil was San Antonio coal from New Mexico.

# ADVANTAGES OF GAS ENGINES FOR CENTRAL-STATION WORK

CHARLES H. WILLIAMS

The term "Gas Engine" brings to the mind of most of us the image of a small machine, such as is frequently made use of to furnish the necessary power for driving such isolated pieces of machinery as are found in small carpenter shops, bakeries, dairies, printing offices, or repair shops, with occasionally a small dynamo used for electric-lighting purposes; this latter as a kind of a side issue, the engine having been installed primarily to perform some of the above-mentioned duties.

The gas-engine central station is such an unusual installation that it is looked upon by all with curiosity, and by a very large majority with curiosity coupled with a lack of confidence.

Central-station work demands such absolute continuity of service, and the results are so disastrous when that continuity is interfered with, that central-station men are generally very slow to adopt anything that has not the mark "tried and accepted," stamped upon it; and hence it is that in this country very few central stations are depending entirely on gas engines for their motive power.

We learn, though, that England, Germany, Belgium, France and Prussia,—whose engineers are usually less adventurous along experimental lines than our own—driven by necessity, have taken up, developed and are now making quite general use of gas engines, and central stations of several thousand horsepower are not unusual in those countries.

Very rapid advances are now being made in this country, and a few years at most will find the gas engine as firmly and reliably established with the American engineer, as is the steam engine of the present day, for the question of fuel economy is impressing itself more and more forcibly upon us, and it is the gas engine which offers us a reliable and effective means of bringing about this desired increased economy.

The efficiency of the gas engine has already been carried far beyond that of the steam engine, and the margin of possible improvement is considerably greater. With prevailing steam pressures, the theoretical efficiency of a steam engine is not equal to the actual working efficiency already obtained with gas engines. If we assume a boiler pressure of 150 pounds absolute and an exhaust pressure of three pounds absolute, perfect theoretical development of the steam engine would give us but 26.5 per cent of the thermal energy which is transformed into mechanical work, while 28 per cent has already been obtained with the gas engine.

It has been said by one of the most prominent engineers of the present time—and it is a fact easily demonstrated—that the gas engine, when looked upon from the point of thermal efficiency, stands to-day in the same relative position as did the steam engine in the days of Watt.

When we make a comparison between the gas engine of to-day and the steam engine as it was found during the days of Watt, it is necessary to look at the existing conditions as found at the two periods under consideration. In the days of Watt the steam pressures experimented with were limited to about thirty pounds, and the theoretically perfect engine would then develop about 20 per cent thermal efficiency, and of this about five per cent was obtained. With the gas engine there is a possible thermal efficiency of 75 per cent, of which to-day only 37 per cent, or a thermal efficiency of 28 per cent, has been developed, leaving a possible increase of 47 per cent thermal efficiency for which the coming gas engineer may strive.

It is a fact that the possible efficiency that may be obtained with ideal conditions with a gas engine equal and surpass the possible efficiency of the steam engine, operating with prevailing pressures, some 180 per cent, and even at the present time when we are just beginning to look into the possibilities of the gas-engine field, we are obtaining efficiencies with our relatively crude apparatus which are far better than the best that the steam plant would be able to produce with ideal theoretical conditions, even after the years of careful study and almost endless experimental work which have been put upon it. With these facts in view, we cannot but admit that the subject is one of the greatest interest and importance to us.

Let us follow the action of the two types of apparatus, that we may more readily understand what these statements mean. With the gas-engine station we must first convert our coal or other fuel into gas. The technical efficiency of a coal-gas plant has never been demonstrated, and its commercial efficiency depends almost entirely upon local conditions and the relative price paid for coal, together with the selling price of the residuals, which are coke, tar and ammonia. Coal gas is manufactured by the destructive distillation of coal in hermetically sealed retorts, which are externally fired. Good gas coal will yield about 10,000 cubic feet of gas per ton of coal, together with about 1,350 pounds of coke, ten gallons of tar, and four to five pounds of ammonia gas. This gas needs only to be thoroughly washed for gas-engine use, and it makes a very desirable gas-engine fuel.

Water gas is manufactured in a steel shell lined with from twelve to twenty inches of fire brick, or other heat-resisting material. Coke or hard coal is generally used for gas-making purposes, and the shell is charged with from four to seven feet of fuel, which is brought to a high temperature by means of a blast of air, forced through the hot coke or coal in the generator. The process is intermittent, and it is customary to blast for about three minutes and make gas for about five minutes. The gas is made by passing steam through this incandescent bed of fuel; the steam is decomposed, and the oxygen unites with the carbon of the fuel to form CO, and the hydrogen of the steam passes on as free hydrogen gas.

Illuminating gas is made from water gas by adding to it hydrocarbon gases or vapors, which are usually obtained from petroleum or some of its products. The apparatus essentially consists of a generator and superheater internally fired, the superheater being heated by the secondary combustion from the generator, and the heat stored up in the loose brick checker work of the superheater is used in the second part of the process to make permanent the hydrocarbon gases; the second part of the process consists of passing steam through the generator fire and of admitting oil at some point between the fire of the generator and the loose brick filling of the superheater.

In Europe, water gas is making some progress owing to its cleanliness, high flame temperature and ease of transmission. The Delwick-Fleischer process promises the best results. An ordinary water-gas machine will give about 60 per cent of the value of the fuel in the gas. The Delwick-Fleischer will do better than this, and its advocates claim from 75 per cent to 80 per cent efficiency. The ordinary water-gas process burns the air of the blast to CO, producing about 4,360 B. T. U. per pound of fuel consumed. In the Delwick-Fleischer process an excessive blast pressure is used, which gives a high velocity to the blast, and it is claimed that nearly all of the carbon is burned to $CO_2$, yielding 14,544 B. T. U. per pound of carbon consumed.

The higher efficiency may be explained by the assumption that carbon and oxygen coming together will first burn to $CO_2$, but in passing through a thick fuel bed, this $CO_2$ in the presence of incandescent carbon will be reduced to CO. A certain molecular time contact is required for this reduction, and if the blast is given sufficient velocity, this reduction will not take place.

Straight water gas is not a desirable fuel for gas engines, owing to its high flame temperature and low ignition point. Any gas containing more than 30 per cent of hydrogen will ignite at a very low temperature, and will not prove a particularly desirable gas for gas-engine work; but as water gas has some very pronounced advantages for other industrial uses, such as welding, brazing, and work requiring high flame temperatures, I look to see it used to drive gas engines, also in industrial plants to avoid duplication of gas-generating processes.

The most likely method of manufacturing gas for gas-engine uses is what is known as the producer-gas system. This has so many modifications that I will attempt to describe but two of them. The first is the simple manufacture of producer gas. In this hard coal, coke or bituminous coal may be used as fuel, and it is charged into a steel shell lined with firebrick similar to the previously described apparatus used for making water gas. The process of making producer gas is continuous, and the gas is manufactured by the continual introduction of air and a small amount of steam into the generator. Roughly, three or more pounds of carbon are gasified by the oxygen of the air to each pound of carbon which is gasified by the oxygen of the water. It is necessary to supply enough heat by the combustion of the carbon with the oxygen of the air to supply the heat absorbed in the decomposition of the water introduced, and to enable proper temperatures to be maintained for the continuation of the process. This system of gas manufacture is capable of delivering from 80 per cent to 85 per cent of the heat of the coal in the form of gas.

Another system of gas manufacture which has met with some favor is a combination of water gas and producer gas.

The thermal value of these various gases will be about as follows:

Coal Gas, 620 to 680 B. T. U. per cubic foot.

Water Gas, 325 B. T. U. per cubic foot.

Carbureted Water Gas, 600 to 625 B. T. U. per cubic foot.

Producer Gas, made from coke, 100 to 120 B. T. U. per cubic foot.

Producer Gas, made from soft coal, 110 to 130 B. T. U. per cubic foot.

Combination Producer and Water Gas, 130 to 160 B. T. U. per cubic foot.

The calorific rating of gas should not be on the gas per foot, but should be on the gas with sufficient air added to produce complete combustion. This would give us the following values for each foot of explosive mixture for the various gases enumerated above:

Coal Gas, 105 to 115 B. T. U. per cubic foot.

Water Gas, 75 B. T. U. per cubic foot.

Carbureted Water Gas, 204 to 212 B. T. U. per cubic foot.

Producer gas made from coke, 25 to 45 B. T. U. per cubic foot.

Producer gas made from soft coal, 27 to 32 B. T. U. per cubic foot.

Combination Producer and Water Gas, 66 to 82 B. T. U. per cubic foot.

It may safely be assumed that coal gas or water gas will never be used for gas-engine purposes except under special conditions, and I will therefore make comparisons with a gas-engine station operated with producer gas.

A simple form of gas producer plant in stations below 1,000 horse-power will cost more for producers and storage capacity than would an equivalent boiler plant. Above this capacity it may cost more or less, depending upon the storage capacity demanded for the sake of uniformity of gas or to insure continuity of service. For uniformity, I am inclined to think that storage capacity should be provided to operate engines for one-half hour at full load; for continuity of service, it would be purely a matter of discretion; although I see no reason why any storage capacity should be provided, except where the gas-engine plant is used as a relay station for a hydraulic or steam generating plant, as a gas producer could be kindled, blasted, and making gas, all within twenty minutes.

As previously stated, an efficiency of from 80 per cent to 85 per cent may reasonably be expected. This system of power production should at least cut your fuel bills in two, and necessarily the aggregate amount of fuel used would be then at least 50 per cent less than if used under boilers. With producers the coal is all handled in large quantities, and it should increase the productiveness of labor at least 100 per cent. In other words, if with hand firing under boilers you can handle five tons of coal per day per man, you should be able to handle with a producer plant at least ten tons of coal per day per man; this would be equivalent to reducing this portion of your labor to twenty-five per cent of its original amount. If low-grade, small-sized coal is used in your producers, you will have a capacity of but from ten to twenty pounds of fuel per square foot of grate surface per hour; but with coarse coke or hard coal, your capacity will be from 40 to 60 pounds of fuel per square foot of grate surface. It is also possible by this method of gas manufacture to recover a certain amount of tar and ammonia, which would slightly reduce your expense for fuel. Large quantities of ammonia may be produced by using the Mond process, to which frequent reference may be found in both foreign and American gas-engineering journals.

Neglecting the matter of residuals, you may assume that with a coal containing 14,500 B. T. U. per pound, you can deliver at your engine 80 per cent or 11,600 B. T. U., and you may also assume that this 11,600 B. T. U. will develop in a gas engine one B. H. P. when operated at full load capacity, hence, we have a B. H. P. for one pound of fuel. You may also be able to make a saving by locating the producer gas station at a point best situated for the reception of coal and the disposal of ash; this arrangement would prove especially valuable for direct current stations having one or more generating plants, which must for other considerations be located at points not favorable to the cheap production of power. Large volumes of gas can be transmitted without heavy investment, and with a small expenditure of energy.

It is possible to provide storage capacity for gas at an investment cost of practically $100 per thousand cubic feet, and taking a gas with a thermal value of 110 B. T. U. per foot, this would give you a storage capacity investment of about $10 per horse-power-hour capacity, while the storage of steam in any large quantity is impossible, and the storage of current by means of storage batteries would amount to about $100 per horse-power hour.

The conductivity of a cylindrical pipe increases very rapidly as you increase the diameter, more rapidly than would be indicated by the increased area, which, of course, increases as the second power of the diameter, while the conductivity of the pipe increases as the 2.5 power. This is explained by the fact that the walls of the pipe, which constitute the retarding element, increase only as the arithmetical proportion to the diameter, while the area of the pipe increases in geometrical proportion.

When the writer accepted an invitation from your programme committee to prepare a paper on this subject, he believed he would have an opportunity of setting before you for comparison the results obtained in a fairly efficient steam plant and also the results obtained in a fairly efficient gas-engine plant; both under the same management, and both operated for the best possible results. These plants are located at Madison, Wisconsin, and are used to supply municipal and commercial lighting for that city, and also railway and commercial power. The steam plant has been in operation for a number of years, and the gas-engine plant has only been in operating condition since early in February, and owing to unexpected conditions, the load has been too heavy since the completion of the gas-engine plant to transfer certain generators which are now in use at the steam station to the gas-engine station where it was intended to use them; for this reason, no such valuable comparison can be made as was originally intended. I shall therefore have to treat the subject from data gathered from careful tests on our steam plant and such data as we have been able to gather from running our gas-engine plant underloaded; but these latter will be supplemented by data gathered from other gas-engine stations with which the writer is familiar, and many of which were visited by him prior to the decision made by the Madison Gas and Electric Company to install gas engines for central-station work.

The steam station at Madison is of about 1,600 horse-power capacity, composed of four Russell, tandem compound engines, operated condensing. The boilers are of the Hazelton and Sterling makes, and three Wainwright heaters are used, together with two Davidson condensers. The load carried is a very fair example of that met with in a light and power station that supplies railway power as well as commercial power.

For convenience, we may consider our gas-generating station analagous to our boiler room, and our gas engines and steam engines may be compared without distinction, as they are both forms of heat motors not greatly different from an operating standpoint.

The following is a very fair example of the results obtained by a number of tests carried on at the steam station.

The coal used had a thermal value of about 14,500

B. T. U. per pound, and when we made a balance sheet of the energy supplied to the system and the energy expanded in the system we found the following:

| B. T. U. SUPPLIED | | B. T. U. EXPENDED | |
|---|---|---|---|
| Heat in coal | 14,500 | Lost at boiler | 4,349 |
| Heat returned to boiler | 761 | Used by auxiliaries | 290 |
| | | Lost in pipes | 168 |
| | | Lost in exhaust | 9,309 |
| | | Friction of engine | 137 |
| | | Useful work | 1,008 |
| Total | 15,261 | | 15,261 |

Referring to the balance sheet, we find that 28.5 per cent of the heat supplied to the boiler, due to the energy in the pound of coal, escapes by radiation from the exposed surfaces of the boiler and furnace, by the heated cinders falling to the ash-pit unconsumed, by incomplete combustion and by the sensible heat of the outgoing flue gases, leaving 71.1 per cent as given up to the water and steam in the boiler and representing useful work, indicating a boiler efficiency of 71.5 per cent.

For every pound of fuel consumed, 5.25 per cent are returned to the boiler by the preheating of the feed water, from a portion of the heat contained in the steam before it reaches the condenser, and by heat absorbed from the exhaust of the various auxiliaries; and when considering the amount of heat entering the engine room, this amount has to be added to the heat leaving the boiler due to the original pound of coal under consideration. We find 1.9 per cent is used to drive the various auxiliaries; 1.1 per cent is lost by radiation and transmission in the pipes; while 61 per cent escapes in the exhaust. It takes .9 per cent to overcome the friction of the engine itself, and this leaves us but 6.6 per cent for developing useful work at the fly-wheel.

Our efficiency of energy transformation is, therefore, 6.6 per cent, and this result was obtained under favorable average working conditions; and while this efficiency may look low to a great many station men, it probably represents much better than average conditions, as can be attested to by numerous engineers whose theoretical ideals have been badly warped by commercial considerations and bad and variable load demands. I am satisfied that we should not be placing our figures too low by assuming that a well-equipped station using compound-condensing engines will transform about seven per cent of the total heat of the coal to useful work, and with simple engines operating condensing the efficiency will be about five per cent, while a large majority of the smaller stations in operation throughout the country will not transform more than 2.5 to four per cent of the energy of the coal into dynamic energy.

In the gas-engine station we also meet with very large losses, for of the 100 per cent of energy which is supplied to the engine through the heat contained in the gas, we find from a number of tests at full load that practically 31 per cent are carried away in the cooling water; and this is necessary to keep the temperature of the cylinders and pistons down to a point where it is possible for them to operate. If no cooling water were supplied, the temperature in large engines would reach a point above the melting point of the metal itself. About 43 per cent is carried away in the form of sensible heat in the exhaust gases, and by radiation from the engine cylinders, This leaves us about 26 per cent doing work in the engine itself, or it leaves us, as we shall see later, 20.8 per cent of the original number of heat units contained in the pound of coal that was put into the gas generator, or 3,016 heat units, for useful work against 1,008 for steam. As both the gas engine and steam engine are purely heat engines, the amount represented by the heat units available for useful work gives us an exact comparison of the relative values of the two types of apparatus.

A pound of fuel has a certain amount of stored energy which may be transformed into heat and finally into dynamic energy, and that method which transforms the greatest amount of stored energy in the coal to dynamic energy is the best method for us to use.

With the gas engine, one is not dealing with high pressures in any part of the apparatus except within the cylinders and in the air reservoir, where compressed air is used for starting, while in the steam plant there is in the steam boiler and pipes a tremendous amount of pent-up energy and, consequently, an increased amount of danger, and the cost of maintenance is necessarily increased by the use of these high pressures. With the gas-engine station, the piping has only to be such as will withstand ordinary low or atmospheric pressures, and there is very little danger from the gas pipes on account of gas explosions, for the reason that the gas of itself is not explosive, and it is necessary to have a mixture, and a certain definite mixture, of gas and air in order to make the gas explode,

A gas pipe that is under pressure greater than that of one atmosphere may be opened to the air, and a flame applied, with the result that the escaping gas will burn and it burns because it receives oxygen from the air; but the flame will not follow back into the pipe, and there is no danger from an explosion within the pipe, for the reason that the gas within the pipe exerts a greater pressure than does the air without, and consequently the air cannot force itself back into the pipe. As a matter of fact, there is no more danger from the pipes in a gas-engine station than there is to the pipes that are found in nearly all of our houses supplying gas for domestic or illuminating purposes.

That the gas is not explosive when not properly mixed with air is very clearly demonstrated by the fact that unless the mixing valves on a gas engine are properly adjusted, one cannot get the gas to explode at all, whereas, if they are properly adjusted, a very small electric spark will cause it to explode and burn the entire contents of the cylinder at a flash.

The possibilities of utilizing a part of the great amount of heat which is carried away in the cooling water has been demonstrated in some instances. In the gas-engine station at Mankato, Minn., the cooling water is passed through a system of hot-water heating pipes, and useful work is done by this lost heat in raising the temperature of the engine room, office and gas works; and there is no reason why the pipe carrying the jacket water, after leaving the engine, could not be brought into communication with the exhaust gases themselves, and thus raise the temperature of the cooling water to a very high degree, and this water be used either for heating or for some commercial purpose.

At the Madison station there is a triplex motor-driven pump which takes water from the several gas-holder tanks, and after passing it around the cylinders of the gas engines it carries it back to the holder tanks, where it is circulated. This relieves the gas works of supplying live steam to these tanks in the winter time, which has been necessary in order to maintain the proper temperature. This of itself means a saving of some $240 per year. The water here performs a double service: that of cooling the cylinder jackets and of raising the temperature of the water in the gas holders.

The item of attendance will enter largely into the problem of comparative economy, and on this point the gas engine has no disadvantage in the engine room, and a considerable saving is made in the generation of gas as compared with the generation of steam.

One type of engine manufactured has three vertical cylinders, and is so constructed that by means of a very simple mechanical device, necessitating the use of but a single lever, the valve which admits the explosive mixture to the right-hand cylinder is cut off, and at the same time this cylinder is put into communication with a compressed-air reservoir; this cylinder then acts as a single-acting air-motor, which puts the engine in operation. At the first revolution the two remaining cylinders take in charges of an explosive mixture of gas and air, which are exploded at the proper point. As soon as the engine starts to turn over and take in gas, the exhaust valves, which have before remained open in order that the air-motor cylinder should not have to do work on the other two cylinders by compressing the charge before the engine has received sufficient momentum to carry the pistons past the point of compression, are now closed, so that the charges are compressed, and when the electric spark ignites them, the engine comes up to speed very rapidly.

Very little practice is necessary to train an attendant to start an engine and bring it to full speed ready to close the generator switch, so that it may take its share of the load in one-half of a minute. This may very easily be done when the electric generator is excited from some apparatus not of itself dependent on the starting of the gas engine, such as the storage battery, or another generator already in operation; some electric generators are sluggish in coming to full excitation, and the time constant that enters here should not be charged against the gas engine. Just as soon as the first charge of gas is fired, compressed air is cut off from the air-motor cylinder, and that cylinder is then ready to do useful work with the rest.

The ease with which gas engines may be started and thrown into service, together with the absence of expense when the machines are standing idle, is of very great importance, for nearly every station has loads at times which cannot be relied upon; loads which may perhaps demand the entire station capacity, and yet are so uncertain that the station man hesitates to keep sufficient boiler and engine capacity just on the verge of working, using tons of coal, only to keep the apparatus in such shape that the station is ready to serve. As these loads oftentimes come on but for a comparatively short time, the gas engine offers a very simple solution to the problem; when not working, using no fuel, and when working using much less fuel 'than the steam engine which it is bound to supplant.

The ease of starting is not limited to the smaller sizes of gas engines, for it is just as easy to put the large engines into service as it is to start the smaller ones, and the larger ones can also be started and put into operation within half a minute.

As before stated, when a gas engine is not in operation, we do not have an active loss such as is unavoidable in a steam-engine plant. The gas-generating apparatus may be operated continually, and the excess gas stored for future use, and the instant a demand is made for power, the engines may be put into service without any preparatory work, such as warming up pipes and cylinders in a steam engine, as is commonly necessary after the load has been for a short time cut off.

One advantage that the steam station is commonly supposed to have over the gas-engine station lies in the fact that the gas engine is necessarily built much heavier per unit of capacity than is the steam engine; this is necessary on account of the high compression commonly used in a gas engine. The pressure in the cylinder at the time of explosion often reaches 500 pounds, against 150 to 200 pounds for steam; and the gas engine must also be built to withstand back firing, or premature explosions, should they occur, as they are liable to do in case the compression is carried too high, or the mixture not properly adjusted. All these things tend to necessitate an increased strength and weight in the working parts, and as the friction load of the engine varies but little from no load to full load—or in other words, as it takes about as much gas to run the engine itself and overcome the friction on the bearings, whether the engine is running light or whether it is doing useful work and delivering its full capacity of power at the fly-wheel—it follows that when the engine is but lightly loaded the total amount of fuel used for each horse-power delivered is large compared with the amount of fuel per horse-power when the engine is full-loaded. It also follows that it is necessary to have the engines proportioned to the amount of load more carefully than in steam-engine work, but it is a fact that the efficiency of the different-sized gas-engine units does not fall off so rapidly as does the efficiency of the smaller steam engines.

Returning, then, to the fact that a number of small or medium-sized gas units can be operated at a higher point of economy than the same-sized steam engines, and can be started and stopped as the load comes on and drops off, it is plain that with properly selected units the gas engine need not vary in economy with a variable load, even so much as does a steam equipment.

Although the gas engine seems to offer a special inducement to a company where the gas and electric interests are one and the gas and electric plants can then be operated as one station, still there is a proposition brought out by the gas-engine station which cannot help but interest a gas company, even though it be a competing company in the lighting business.

Consider a steam plant generating electricity, using coal under its boilers, and a gas company in the same town furnishing gas for illuminating, domestic and industrial purposes. The gas company has a good proposition in its hands when it agrees to sell gas to the gas-engine station at a slight increase over the cost of gas in the holder, for the increased profits it receives on all its regular customers without altering the price to them is a sufficient inducement to give the electric company this gas at a reasonable figure; and although it may cut the cost of generation for the electric company by an amount whereby they may be able to sell their product at a more reasonable rate, it still places even a greater profit in the hands of a gas company, for if they were realizing a profit before, they can now realize a much larger profit, and be able, perhaps, to cut their prices so as greatly to increase their domestic and industrial gas sales, and thereby compound their earnings.

People want electric lights, and if the rates are reasonable, they are going to have them regardless of the inducements offered by the gas companies; the gas companies can therefore do no better than to encourage this type of gas consumer, and at the same time place themselves in a position whereby they can deliver their product to their consumers at a price where the consumer cannot afford to be without it.

The writer can cite an instance in his own city where the fuel-gas business has been pushed to the extent where there are now installed 2,000 four-hole gas ranges. This for a town of 19,164 inhabitants means one gas stove, and a little more than one, for every ten inhabitants. Surely the introduction of the gas engine will not have a detrimental effect on the gas business, even though it will cheapen the cost of generating electricity, for the gas engineer will only be using his product in another way, and in a way which will increase, rather than diminish, his earnings.

There are two plants using coal gas upon which accurate figures have been obtained, and which are of considerable interest to us. The plants referred to are those located at Mankato, Minn., and Oshkosh, Wis. In both these cities the companies were operating electric plants, and were also operating gas plants, and after the gas-engine stations were installed, these furnished all the power for the electric stations. At Mankato there were installed one 85-horse-power and one 125-horse-power gas engine, and recently there have been added two additional 50-horse-power engines; and although the installation is but a comparatively small one, it offers some very interesting data.

The load for which these engines furnish power consists of 107 32-candle-power street lamps burning 3,000 hours per year; sixty-three 2,000-candle-power open arcs, 35 commercial multiple arcs, 1,800 sixteen-candle-power incandescent lamps, together with the commercial power load of 60 horse power.

At Mankato the gas company did not operate a steam station previously to installing their gas engines, but bought their power on a flat rate from a milling company. As we do not know whether the price they paid, $7,200 per year, was reasonable or not, we can not make any direct comparison on that point, but we can draw some valuable information from the Mankato company's books in regard to the cost to the company, for the gas used in the engines, and the saving effected by the company, through the decrease in the cost of manufacturing the gas per unit after they had increased their sendout by manufacturing gas for their own use, over the amount which it has cost them when they were only supplying their regular customers. The books show us what it cost the company to put the gas in the holder before and what it cost them after they increased their sendout. They show us that the amount of gas used for the six months ending January, 1902, was about 78 per cent increase over the previous gas sendout. They show us that this 78 per cent increase in sendout lowered the cost of the gas to the company eight cents per thousand, which was exactly the same as giving them an additional profit of eight cents per thousand on every thousand sent out to their regular consumers.

It is perfectly legitimate for that company to credit the gas-engine account with eight cents per thousand on 16,000,000 cubic feet of gas, that being their annual sendout, or $1,280 per annum, and this credit amounts to 18 per cent of the total amount which they had paid for power previously.

At the Oshkosh plant they have installed two 50-horse-power and two 125-horse-power gas engines, and here they were sending out 45,000,000 cubic feet of gas annually. The extra output of gas here lowered the cost of gas in the holder eight cents per thousand again, so that the gas engines should be credited with $3,600 per year, due to decreased cost in gas generation.

There are also installed two engines at Red Wing, Minn., two at La Crosse, Wis., and three at Appleton, Wis., all running on illuminating manufactured gas; but the last three stations have not been installed a sufficient length of time to furnish any valuable information.

The plants thus far mentioned as operated on artificial gas were taken up to show the possibilities along that line, but three-quarters of all the gas engines operated in this country that come under the head of central-station engines, are found in either the natural-gas fields, or receive their gas from gas producers.

The Consolidated Gas Company, of New York, has a gas engine belted to two exhausters which operate continuously, but with a variable speed. Here, there is an automatic governor actuated by the pressure of the gas; and as there is a different quantity of gas passing the exhausters at different intervals, the engine must be automatically regulated to maintain the pressure constant. This engine answers every requirement in this line, and operates days, nights and Sundays. It has a record of continuous operation of 1,157 hours, when it was shut down to repair a broken belt.

A 650-horse-power gas engine, direct connected to a generator of suitable size, is found in the power house of the Homestead Steel Works, near Pittsburg, Pa. This engine does almost constant duty, and running day and night, as it does, without any trouble, certainly speaks well for the reliability of this class of machines. It has a heavy but variable load, the kind of a load that brings out the weak points of an engine if there are any to be brought out, but this machine has given such service that the management does not hesitate to endorse it in the highest terms.

Scattered all through the gas fields are found engines of different types and sizes; some very large ones, built not with regard to close regulation, such as electric plants demand, but for heavy duty and continuous service. They are used to pump the oil from the oil fields to the points where it is to be refined. And there are engines there whose records for long time of running compare favorably with the large steam pumping engines.

One central station operating on natural gas, from which I was able to get definite information as to the results obtained, was that of the Bradford Electric Light and Power Company, of Bradford, Pa. Here there are three 150-horse-power and one 210-horse-power gas engines which have been in operation for three years, and that company is just installing an additional 210-horse-power machine. Mr. J. H. Rose, who is manager of the plant, is a very enthusiastic supporter of the gas engine for central station work, as an extract from a letter from him to the writer will show. He says: "I want to start right in by saying that during the three years we have never had an engine lay down, nor has one ever refused to start promptly. To use an expression of the hour, the gas engine has a steam plant skinned forty ways. This may not be a genteel expression, but it certainly has no ambiguous meaning.

"Before adopting the gas engines, we were operating our plant with steam, using horizontal tubular boilers, and high-speed engines. The boilers were fired with gas. The last test made of our steam plant was made under the most favorable conditions, that is, we prepared for the test. The gas per i. h. p. was 51.09 cubic feet, while with our gas engines, the consumption per e. h. p. was 13.6 cubic feet, which, if re duced to mechanical horse power, I estimate would be between 11 and 12 cubic feet.

"The above figures will give you an idea of the saving we have effected in our fuel, to say nothing of boiler and other repairs incident to a steam plant.

"Our gas-engine repairs for the year 1901 amounted to $196.90, including extra exhaust valves for all engines, and other parts not as yet used. The difference in inventory would probably not exceed $100 for the year."

After going on in detail with some other information, not of interest in connection with this paper, he concludes by saying, "I can only add that our gas engines are giving us perfectly satisfactory service, and I should dread going back to steam."

The Winchester Repeating Arms Company, of New Haven, Conn., is a prominent concern that has undertaken the introduction of the gas engine in their factory. They now have in use one 80-horse power and a 125-horse-power gas engine, and have ordered three additional 164-horse-power machines which will be direct-connected to generators. These engines are operated on producer gas, as this company uses producer gas for its annealing ovens, forges, and other like purposes. This installation is, I believe, a very interesting one, as it is built on lines that will probably be followed extensively from this time on.

In conclusion, I will say, that so far as the question of reliability of operation is concerned, I believe the early manufacturers are more to blame than anyone else for what trouble there is along this line, for the reason that while experimental work was being done on the gas engine, far too many of the small units were sold with the assurance that "anyone can run it." The same advice carried out at the steam station would put it on losing basis. There are a few, a very few, small details which demand intelligence and regular attendance in the gas engine, and if these proper conditions are maintained the engine will operate satisfactorily, and the attendant's troubles are over.

MR. DOHERTY: I move that the next convention of this association be held in Chicago, in May, 1903. In explanation of that motion I will say that this convention should have been held there, and out of courtesy to President Ferguson I should like to have the next meeting of the association held in Chicago. I think it is a better convention city than New York, and it will be advisable for us to go there for many reasons.

MR. DUSMAN: It seems as though our eastern friends should have some consideration. This year in Ohio, the next in Illinois, and the following year in Missouri puts three conventions in succession rather far west.

MR. HAY: That would ordinarily be correct; but going to St. Louis is not an ordinary convention.

MR. MAUNSELL: In regard to Mr. Dusman's suggestion that the convention be held in the east, I think we ought to take into consideration that Chicago is in the east considerably. There are some gentlemen here from California, one or two from Colorado, and I am here from Kansas. I think there are many who would like even a more central location than Chicago.

MR. MCGEE: As the subject has come up of getting in small companies as members, I feel that we have in our western country very many small companies that will come in if the meetings are kept in a central location. It is hard on the representatives of small companies to have to travel very far. As an officer of the Iowa State Association, I have reason to know and feel the pulse of the different small stations in our state, and I am sure it will be to our advantage to have the next convention in Chicago.

(Mr. Doherty's motion, to have the convention of 1903 in Chicago, was unanimously carried.)

Secretary Cahoon then presented the following:

### REPORT OF THE SECRETARY AND TREASURER

#### RECEIPTS

| | | |
|---|---|---|
| Active membership dues | $3,867 50 | |
| Associate membership dues | 1,280 00 | |
| | | $5,147 50 |
| Sale Reports Twenty-fourth Convention | $200 00 | |
| Sale Badges Twenty-fourth Convention | 111 00 | |
| Advertisements in proceedings | 265 00 | |
| Municipal fund | 295 00 | |
| Received account municipal fund | 25 00 | |
| Received from publication | 118 44 | |
| | | $1,014 44 |
| Total receipts | | $6,161 94 |
| Balance in bank January 1, 1901 | $6,019 58 | |
| Debtor to petty cash January 1, 1901 | 17 94 | |
| | | $6,001 64 |
| | | $12,163 58 |

#### DISBURSEMENTS

| | | |
|---|---|---|
| Salary of Secretary | $1,000 00 | |
| Office rent | 420 00 | |
| Stenography and typewriting, including report of Twenty-fourth Convention | 1,669 95 | |
| Printing and stationary, including proceedings and papers read at meetings | 1,937 71 | |
| Postage and telegrams | 264 55 | |
| Traveling expenses | 192 63 | |
| Sundry expenses | 23 27 | |
| Badges Twenty-fourth Convention | 128 50 | |
| Municipal fund | 12 50 | |
| Photometric investigation fund | 100 00 | |
| Furniture | 51 00 | |
| Testimonials | 25 00 | |
| | | $5,825 11 |
| Net cash balance | | $6,338 47 |

| | |
|---|---|
| Balance in bank January 1, 1902 | $6,332 58 |
| Balance in petty cash January 1, 1902 | 5 89 |
| | $6,338 47 |

ASSETS

| | |
|---|---|
| Cash as above statement | $6,338 47 |
| Office furniture, as appraised by finance committee | 266 00 |
| | $6,604 47 |

LIABILITIES

None

PHOTOMETRIC INVESTIGATION FUND

| | |
|---|---|
| Balance | $133 50 |
| Advance to committee | 100 00 |
| Balance | 33 50 |

MUNICIPAL FUND

| | |
|---|---|
| Balance | $2,565 80 |
| Receipts | 295 00 |
| | $2,860 80 |
| Disbursements (printing) | 12 50 |
| Balance | $2,848 30 |

Respectfully submitted,

GEORGE F. PORTER,

Secretary and Treasurer.

(On motion, the report was adopted.)

THE PRESIDENT: I want to thank the members for the support they have given the convention by their attendance at the sessions. The hall has been very hot, and yet we have had the best attendance at our sessions that we have ever had; and that state of affairs is always very pleasing to a presiding officer. If we are to succeed in making this association what we aspire to, have it—and for which we have laid plans at this meeting—we must have it more cohesive than it has been at times in the past. Gentlemen, I thank you for your support.

The convention then adjourned.

# RESOLUTIONS OF THANKS

The following resolutions of thanks have been engrossed and presented to President Henry L. Doherty, Vice-President Charles B. Hunt and Secretary George F. Porter:

WHEREAS, The National Electric Light Association in convention assembled at Cincinnati, May, 1902, is deeply sensible of the splendid work done in its behalf by the president, Henry Doherty, during his term of office and in other executive positions, it is hereby

*Resolved*, That the association place on record its hearty thanks to Mr. Doherty for his self-sacrificing, indefatigable and successful efforts to enhance its prestige and influence and enlarge its sphere of usefulness, and

*Resolved*, That the association further record its appreciation of Mr. Doherty's unfailing courtesy as a presiding officer, his conscientious attendance at all meetings, and his brilliant example as a public-spirited electric-light manager, and

*Resolved*, That these resolutions be not only entered upon the minutes but be engrossed and presented to Mr. Doherty as a tribute, inadequate but sincere, to his worth and work, coupled with the warmest wishes for his personal happiness and prosperity.

LOUIS A. FERGUSON,
First Vice-President,
HARRIET E. BILLINGS,
Assistant-Secretary.

WHEREAS, The National Electric Light Association in convention assembled at Cincinnati, May, 1902, desires to express its sense of appreciation to Vice-President Charles B. Hunt for his faithful and continued service in its behalf, it is hereby

*Resolved*, That the association extends to Mr. Hunt its hearty and sincere thanks for his loyal and persistent work, his intelligent interest in its affairs, and his readiness to bear responsibilities in its behalf, and

*Resolved*, That the association recognizes not only Mr. Hunt's worth as a man but his representative capacity as a fellow worker in the electric-lighting field in the great Dominion of Canada, where the body has enjoyed the most cordial welcome and hospitality, and

*Resolved*, That these resolutions be duly entered upon the minutes and that an engrossed copy be presented to Mr. Hunt, coupled with the esteem and warmest good wishes of all his brother members.

HENRY L. DOHERTY,
President,
JAMES B. CAHOON,
Secretary.

WHEREAS, The National Electric Light Association has learned that, owing to imperative business reasons, Mr. George F. Porter is compelled to tender his resignation as secretary, it is hereby

*Resolved*, That the association takes this opportunity, at its annual convention, at Cincinnati, May, 1902, to express its deep sense of regret at this serious loss, and

*Resolved*, That the association desires to put on record its appreciation of the loyal and intelligent service rendered it by Mr. Porter for ten years, and for the excellent results that have attended his efforts to promote the welfare of the association and the interests of those engaged in the electric-lighting field; and

*Resolved*, That this expression of esteem and good will be entered upon the minutes of the association and be presented to Mr. Porter in engrossed form.

HENRY L. DOHERTY,
President,
JAMES B. CAHOON,
Secretary.

# QUESTION BOX

*1.—Is it possible to operate induction motors for elevator service and other intermittent use from lighting feeders without serious disturbance to electromotive force?*

Yes. Induction motors can be used for elevators and other intermittent services, and if the proper type be installed they will cause practically no more disturbance on the lighting feeders than would be caused by the corresponding direct-current shunt motor for the same service.

RALPH D. MERSHON,
New York City.

My experience is that it is not possible to operate induction motors for intermittent service from lighting feeders without interference with the lighting. My experience includes single-phase up to seven and one-half horse power, three-phase up to 15 horse power. The single-phase motors have been operated from a large system of secondary mains and separate transformers; the three-phase have been operated only from separate transformers, and I have found in all cases that they produce a serious disturbance to the lighting.

W. T. OVIATT,
Bridgeport, Conn.

Our motor business is all three-phase, and we do not allow any elevator service on our three-phase motors unless the motor is running continuously on tight-and-loose pulley, or in case of a hydraulic elevator with a by-pass valve, as it causes too much disturbance in the electromotive force on our generators. I would add that all of our power service is on independent circuits from our lighting.

F. L. SARGENT,
Malden, Mass.

The experience in El Paso with induction motors for elevators has been that the frequent starting and stopping causes the line current to fluctuate to such an extent that it is impossible to do a satisfactory lighting business from the same line. This is not so important if a special power circuit is run, but, as the starting current is often four times the full-load current, it is evident that large generators would be required to take care of a relatively small amount of business.

J. E. BARKER,
El Paso, Tex.

Yes, under certain relative conditions between generator and motors, and if the motor is supplied by an independent transformer or a bank of transformers whose capacity is largely relative to the motor.

J. H. PERKINS,
Youngstown, O.

Induction motors may be operated for elevator service, and other intermittent uses, from lighting feeders without serious disturbance of the pressure, under certain conditions. In Chicago, this class of service is being carried on four-wire, three-phase circuits, operated at 2,200 volts from neutral to phase wire, with 3,800 volts between phase wires. The circuits carrying these motors carry the lighting load on one phase, the size of the wire on that phase and the neutral being designed to give five per cent drop from the station to the distributing centre. The other two-phase wires are No. 6 uniformly, the lighting wires being mostly No. 2 wires. Such a circuit will carry elevators operated by 10-hp or 15-hp motors, without serious disturbance in the pressure at a distance of two to three miles from the station or sub-station.

H. B. Gear,
Chicago, Ill.

There is no difficulty in operating induction motors for elevator service from a central station, provided reasonable precautions are taken to insure good potential regulation. The motors should be of the type having starting resistance in the secondary, and motors with squirrel-cage armatures should not be permitted except in very small sizes, as they take from three to five times full-load current at starting. If the generators are large, the 'bus-bar potential will not vary very materially with any ordinary size of motor. If the generators are of small size compared with the current taken by the motors, constant potential can still be maintained by using a special form alternator or a pressure regulator. Either method will compound the generator automatically and give constant potential under varying load.

We recently had an extreme case at Lockport, N. Y., where a squirrel-cage armature motor of 50 horse power made by one of our competitors, which should never have been tolerated on the lighting system, was operating from a 200-kw alternator. The motor took between full-load and twice full-load current from the generator at starting, and without a proper regulator practically put the generator out of service every time the motor started up. With the regulator, they are able to run this motor without seriously affecting their regulation.

The drop in the feeders should be made as small as possible. I see no necessity for over five per cent with an alternating-current system. Under such conditions, with constant potential in the power house, you are not liable to have serious fluctuations at the ends of the feeders. If a large drop is necessary, automatic feeder regulators should be used.

F. O. BLACKWELL,
Schenectady, N. Y.

## DISCUSSION

MR. CHARLES F. SCOTT: It appears to be the same answer again—it depends on conditions; sometimes you can, and sometimes you can not. That is the true answer, just as is indicated by the variety of answers that have been read. In some stations, where the conditions are favorable, various classes of motors can be operated without interference to the lighting service; in other cases it is not possible. The same statement might be made with regard to direct-current motors. The question might be put: Is it possible to operate direct-current motors for elevator service and lighting on the same circuits? I know of conditions where the induction motor has been criticized for not doing good work on elevators where a direct-current motor would not be used, and in such cases the induction motor is expected to do more than the direct-current motor would do.

*2.—What specification should prevail in purchasing induction motors to insure least disturbance to line electromotive force?*

The type of motor should be that having a rheostat included in its secondary circuit, the rheostat being such that it may be cut out by as great a number of steps as is necessary to keep the disturbance down to the point desired. In specifying the number of steps there shall be in the rheostat and the magnitude of each step, one should follow the course which would be followed in specifying the starting rheostat for a direct-current shunt motor for the same service as that which the induction motor has to meet. In addition, the moter should of course have as high a power factor at all loads, and especially light loads, as is consistent with the maximum torque that will be required of it.

RALPH D. MERSHON,
New York City.

I inclose herewith a copy of the specifications covering the installation of induction motors on the circuits of the Brooklyn Edison Company. These call for motors of five horse power and over, which will give full-load torque with full-load current.

F. O. BLACKWELL,
Schenectady, N. Y.

### DISCUSSION

MR. CHARLES F. SCOTT: With regard to the specifications for purchasing induction motors, specifications are sometimes presented which place the starting current as a certain fraction of the full-load current, independently of the size of the motor. That is evidently not a fair thing, as a circuit that will enable a 10-hp motor to start, taking its normal full-load current, would permit of a 1-hp or 2-hp motor being started with two or three or four times its full-load current, and not make the same disturbance on the circuit that the 10-hp motor would make when starting with only its normal current. It would be better, therefore, in specifications of this kind, to place some limit upon the amount of current that can be taken from the circuit, or to make different specifications for different sizes of motors instead of making a specification that refers alike to all motors. If the starting current is specified in terms of a full-load current, then it may be that a poor motor will pass the specifications and a good motor will not. For example, suppose two motors were used that took the same starting current, but one of them took a considerably greater running current than the other; the one with the greater running current would be the poorer motor, but as it takes less starting current it might pass the specifications where the other motor would not.

The answers to this and the preceding question should come preferably from those operating stations, if they can give their experiences and the conditions under which they get favorable or unfavorable results. The discussion of questions of this kind by men who are doing the work is particularly valuable.

*3.—What has been the experience from use of single-phase induction motors above one horse power on lighting feeders?*

We have in use one 40-hp, one 15-hp and one 25-hp induction motor on our lighting-service lines, with no bad results, although it is true that there is a variation of the voltage in starting and stopping them.

R. J. PATTERSON,
Waterville, Me.

Before having our power circuits completed we had several single-phase motors on our lighting feeders, from one and a half to five horse power, and they have caused us no trouble.

F. L. SARGENT,
Malden, Mass.

A 15-hp single-phase induction motor caused no disturbance in regulation; at least, no complaints were received that could be attributed to it. The motor was in use for five months prior to December 24, 1901, and was used for operating a stone crusher.

W. J. GREENE,
Cedar Rapids, Ia.

We have had a 15-hp single-phase induction motor running a pump, current being generated at water-power station five miles away. Every time the motor is started or stopped every incandescent light in town is affected. It is a great nuisance. The question might well be: What is the remedy?

C. E. BURROWS,
Walla Walla, Wash.

The largest single-phase induction motor that we have on lighting feeders is three horse power. We have had no trouble from motors up to this size interfering with the regulation on the lighting system. We have had no experience with larger sizes.

H. J. Gille,
St. Paul, Minn.

Up to sizes on our lines—20 horse power—we have found them satisfactory in every way, and they will do all that can be done with a multiphase motor. They have an advantage in requiring only two wires and one transformer, which makes the cost of installation less and makes it economical to reach out-of-the-way places as well as the points near the centre of distribution. Motors that have been in service some three years have never caused repairs or trouble. Relative to this question, we might say that we would rather have ten alternating-current motors on our line than one direct-current. We now operate 500-volt direct-current and both single and multiphase motors.

J. H. Perkins,
Youngstown, O.

The entire alternating-current distribution of this company is single-phase. In the concentrated business district we have the transformer secondaries cribbed on a three-wire system, this network being fed from large transformers, the primary circuits of which are independently controlled from the station distribution switchboard. This network is of ample capacity for almost any demand that may be made upon it, and throughout this district it has been our practice to place no limit upon the sizes of single-phase alternating-current motors installed. We have several hundred single-phase motors operating with entire success on this underground network, a number of which installations have individual units as high as 35 horse power, with individual customers taking as high as 75 to 100 horse power for motor service alone. Practically all of these motors are of the ——— company's type, wound for 208 volts. In starting they are thrown on 104 volts, on which pressure they run up to about two-thirds speed, and are then thrown over to the 208-volt feeders.

We have no difficulty from operating incandescent lamps and single-phase motors on the same service feeders, and the use of single-phase motors in preference to other methods has enabled the company to simplify very greatly its general distribution system. In the outlying districts of the city our alternating feeders are of 100-kw capacity each. On these circuits we permit the installation of single-phase motors, under our supervision, up to 10 and 15 horse power. In one particular instance we have a 15-hp motor operating satisfactorily at a distance of four miles from the station. It is our practice to require all these motors to be wound for 208 volts, and we exact that they be started on 104 volts in exactly the same way as in the down-town district. By careful supervision of these outlying installations, we have been able to take on a great deal of alternating-current-motor service without detriment to our lighting distribution.

In our opinion, the single-phase motor of to-day is a thoroughly practical and satisfactory machine, and if installed with intelligent supervision it affords a means of securing a very satisfactory alternating day load from districts into which it would be expensive and inconvenient to carry either multiphase alternating or direct-current systems of distribution.

MISSOURI-EDISON ELECTRIC COMPANY,
St. Louis, Mo.

Our experience with single-phase induction motors above one horse power on lighting feeders has been quite satisfactory. We have a number of these motors installed, and by putting in sufficient transformer capacity, as recommended by the companies furnishing the motors, we find no difficulty or inconvenience in installing them on our light feeders and think their use beyond our regular power circuit quite a help.

QUINCY GAS AND ELECTRIC COMPANY,
Quincy, Ill.

Single-phase motors of one to three horse power are being operated for general power work from lighting feeders in large numbers in Chicago. Such motors will often produce, when started, a dip of about five per cent in the primary pressure, but as these are not usually started more than two or three times a day, and at times when very little lighting is in use, there has been no difficulty with customers' complaints on account of these motors being on the same circuit. Motors of one horse power or larger are carried on separate transformers. In a few instances, installations of several 2-hp motors aggregate 10 to 12 horse power. These motors have been found to affect the shape of the day-load curve very noticeably.

CHICAGO EDISON COMPANY,
Chicago, Ill.

We have two single-phase induction motors of 25 horse power, three of 10 horse power, and two of two horse power. The two 25-hp motors have particularly hard service. One is used to pump water from the city reservoir to the tank, being run after midnight, without attendance, and lifting 15,000 gallons 150 feet high through 6,000 feet of six-inch pipe. The other is used to run a clay grinder in a pottery, and has to contend with a variation of from no-load to 30 horse power every half hour and also a change of six horse power in the load five times every two minutes. These motors are all run from a 60-kw dynamo, and with one exception are all on the lighting feeders. We have never had any trouble with the motors nor any complaints from our customers regarding the light furnished. The motors are in first-class condition, and we see no reason why they will not continue to give good service for years.

WHITE HALL (Ill.) ELECTRIC COMPANY.

Such single-phase motors as have been furnished up to this time have taken excessive current at starting and have had a low starting torque. I should advise putting in multiple feeders, and believe that the three-phase system with a three-phase, four-wire distribution is the best. Where it is necessary to use single-phase motors, those only that have the highest power factor and that take the smallest current should be employed.

F. O. BLACKWELL,
Schenectady, N. Y.

## DISCUSSION

THE PRESIDENT: Mr. Oviatt said these motors were not satisfactory, and included a consideration of them in his answer to question No. 1. Do any of the members desire to discuss this question?

Mr. Arthur Williams: I do not know that this question can be answered under that head, but I should like to know if anyone can say why there should be a material difference in cost between single-phase motors and two-phase or three-phase motors. Why should not the cost of a single-phase motor be more in proportion with the cost of the other type?

Mr. Behrend: Any multiphase motor gives its output with less material than a single-phase motor. You may consider a single-phase motor as a three-phase motor one phase of which is cut out or interrupted.

Mr. Williams: I understand that the answer is simply that there is more material required per horse power in the single-phase motor, and that on that account the cost is more for that motor?

Mr. Behrend: There is a difference between cost and price. You have to compare shop cost and selling price on two entirely different bases. You may be able to sell a three-phase motor for about 50 per cent more than a single-phase motor, but the cost of the single-phase motor is greater than that of the three-phase motor.

The President: The selling price is what the traffic will bear, and not what the apparatus will cost. This is not always the case, but it is sometimes true.

Mr. Williams: I was surprised a week ago to find that a half-hp single-phase motor cost 40 per cent more than a half-hp two-phase motor.

Mr. Behrend: It is perfectly natural that a single-phase motor should cost more than a two-phase motor, because it contains considerably more material.

Mr. R. W. Rollins: Can anyone tell me why the price list on the two-phase induction motor should be greater than on the direct-current motor?

The President: I think I shall call on Mr. Frank H. Taylor, of the Westinghouse company, to answer that question.

Mr. C. C. Badeau: As to the relation between the prices, I know that certain single-phase motors do not sell for more than the three-phase or quarter-phase motors.

The President: Mr. Taylor, we want to know why a two-phase or polyphase motor costs more than a direct-current motor or single-phase motor.

Mr. Behrend: The statement has been made that the single-phase motor costs more than the polyphase motor. I believe that was the question that was asked.

The President: Is the price fixed on what the traffic will bear or on what the apparatus costs?

Mr. Taylor: I think I had better invite some engineers to dinner. I think that is a commercial question, altogether, and I do not understand that we are here to discuss commercial questions of this kind. As I understand it, however, the experience of central-station people with alternating-current motors is about the experience that I used to have as a salesman for Yale locks. There was no apparent reason why Yale locks should cost more than Corbin locks or the locks of any good manufacturer; but no one who bought a Yale lock was ever sorry that he bought it and paid the price for it. The same thing is true of induction motors; the price is not excessive, and anyone who buys one motor buys more and appears to be happier than before.

### *4.—What system of charging best lends itself to the supply of power with induction motors?*

A two-rate system in which allowance is made for the cost of increased investment in generator, transformer and wire capacity, due to the effect of the low power factor.

W. J. GREENE,
Cedar Rapids, Ia.

A consumer should be charged for "readiness to serve" on basis of maximum demand of motor. The maximum demand should, in this case, be considered the demand that would blow a fuse of rated capacity, as distinguished from instantaneous demand.

ANONYMOUS.

### *5.—How may power market be best developed?*

This is a question of making the price right and letting people know it. They all look at the rate, and to make a low meter rate it is necessary to have another charge to make up for the loss due to the fact that the motor is not used all the time, or at full capacity. This is easiest done by a "service charge," as adopted by the Niagara Falls Power Company. Information as to the cost of maintaining and operating steam and gas engines is necessary.

R. J. PATTERSON,
Waterville, Me.

*First*—Arrange the plant and distribution system so as to reduce the manufacturing and distribution cost per kilowatt to a minimum.

*Second*—Present the advantages of electric power to the public through capable solicitors, and show particularly that they can purchase power cheaper than they can manufacture it. E. H. MATHER,

Portland, Me.

By selling motors on a small margin of profit. Where a customer who uses steam thinks of making a change in power, offer to take a few steam indicator diagrams under varying loads, from which calculate the average horse power, and then give him an idea of what it will cost approximately. Nine out of ten men do not understand what a kilowatt-hour means. The price charged, of course, must vary with local conditions, but rates should be such as to be favorable when compared with the burning of coal.

CHAS. H. PETERS,

Durango, Col.

I do not think any general scheme for developing the power market will be capable of universal application. I think the best results will be obtained by employing a competent engineer to solicit power business, letting him apply individual methods to the case of each power consumer who already has a power plant of his own. The greatest difficulty in the way of obtaining power consumers is the fact that they always believe their power is costing them much less than it really is, and they also think they are using much more power than they really are. These two obstacles can be overcome by keeping close track of their costs, and the amount of their power consumption can be obtained by proper engineering investigation. The total power is best obtained by indicating the engine, and the transmission losses are measured by running certain groups of machinery independently on some idle day when the factory is not in operation.

ANONYMOUS.

By putting in the field, as exclusive power solicitors, men who have had some experience in the arrangement and running of machinery, to talk up in detail with the users of power the advantages of electrical machinery; by making it particularly easy for a man to install the service, either by selling motors yourself without profit, or by selling them upon time basis over one or two years with very small interest charge; by assuming that no good business man is going to take up with a new thing at a considerable expense unless the concern that is selling it is sufficiently anxious to get it in to do the walking and talking, and is willing to assume at least part, if not all, of the chances of its being unsatisfactory.

JOHN F. GILCHRIST,
Chicago, Ill.

As a preliminary to inducing a customer to contract for the supply of electric power, it is necessary to have him ascertain as nearly as possible what his power is costing him under present conditions, since in the great majority of cases the proprietor of a manufacturing establishment has most erroneous views regarding this point.

In arranging a schedule of rates, favor as far as possible the customer with a high average demand; the rates for the customer who has a very variable load, or a very high maximum and a low average, being necessarily higher, but still below the cost of power when supplied from an isolated plant.

Make a reasonable reduction in rate as the quantity increases, in order to encourage the large power users to employ electric power in their installations.

Make the bases of measurement the volt-ampere, not the watt, and charge for the input to the motor; as it is only under these conditions that all customers are treated alike.

Have several bases for charging. Quote equivalent rates in several ways, so that the customer may select the one he thinks best suits his particular case.

Cultivate the service field as much as possible by offering good discounts to customers who are willing to shut down their motors in whole or in part during the time of the peak lighting load. In case of fixed and meter rates, take this discount off the fixed portion, where it will be noticed and will be more attractive to the customer. On opening this question of limited service with a customer, he is likely to be somewhat sceptical about the possibility of his doing this; but if proper discounts are allowed, many customers will be found who can take power under this class of contract to the advantage of both customer and station.

P. G. GOSSLER,
Montreal, Canada.

*6.—Does it pay to rent motors, and how should rental price be computed?*

It does not pay to rent motors.

R. J. PATTERSON,
Waterville, Me.

In answer to this question, I would simply say, No.

Most of us are already burdened with plenty of investment, with its attendant fixed charges.

J. W. CARTWRIGHT,
Bangor, Me.

In answer to this question, I would say that I do not consider it wise to place motors on this basis for the sake of the rental alone, on account of the usual rapid deterioration of the motors and the tendency of all people to be rather more careless in their care of rented property, than of that in which they have actual ownership. I believe it is better in every instance to have the ownership of the motor in the user, even if the company has to carry the motor for a considerable length of time, allowing the owner to make payments on instalments, but giving satisfactory surety, such as a lien on the motor itself. There are instances, however, where we have found it necessary to put motors on a rental basis. This has almost always been done for one of two reasons:

*First*—On account of a change in the power service from direct to alternating current and the inability to get the customer to pay a fair portion of the cost of such change. In a few such cases we have placed motors on a rental basis.

*Second*—In cities where no power business has been done, but where it is very desirable to make a start and where the user has a considerable investment in a steam plant, which he is unwilling to increase by the purchase of a motor.

In view of the hazardous nature of these rentals, however, we always base the rental on a sum varying from 15 to 20 per cent of the cost of the motor.

F. P. ROYCE,
Malden, Mass.

I do not think it best to rent motors generally, and I do not think it necessary to do so. In some particular cases power consumers can not be obtained unless some way is found to supply the motor to the proposed consumer without a heavy cash investment.

If a cash sale can not be made, I believe the best scheme is, first, to try to sell the motor to the consumer on the instalment plan, but, failing in this, I would recommend renting the motor rather than losing the customer's business. The rental price of the motor ought to be not less than one-sixth of its cost, unless the profit on his consumption fully warrants a much lower rental rate.

ANONYMOUS.

The writer has had no experience in renting motors, but, while he is very willing to be convinced that it is wise if there is anything in it for the company that he represents, his off-hand judgment is that it is better to sell the motor upon a time basis, which in practice is very like renting, but where the responsibility is thrown more upon the customer and where the customer's sense of ownership leads him to take more interest in the care of the motor than would otherwise be taken and to assume repairs more readily.

JOHN F. GILCHRIST,
Chicago, Ill.

From the standpoint of the supply company that is entirely independent of manufacturing interests, it does not under ordinary conditions pay to rent motors. One of the most important points in connection with the supply of current is to make the service as nearly as possible secure from interruption. Where the motor is supplied by the station the customer, as a rule, makes no distinction between interruption due to defects in the motor and interruptions due to lack of current, and the reputation of the supply company is likely to suffer in this respect. Difficulties arise that are due to neglect on the part of the customer to care for the motor properly, and he is likely to be dissatisfied in the adjustment of the cost of repairs. Induction motors have now reached such a state of development that there is no longer any uncertainty about the investment being subject to heavy depreciation, and there is therefore no reason why a customer should not buy his own motor.

If motors are rented, the rate should be a definite percentage of the selling price, the customer having the option of buying the motor within a given time, being allowed, if he does so, a part of the rental toward the purchase price. P. G. GOSSLER,
Montreal, Canada.

## DISCUSSION

MR. ARTHUR WILLIAMS: We have found it profitable in a few instances to sell motors on the instalment plan, but have never attempted to rent them. It would seem a mistake to attempt the sale of a motor by comparing the cost of electric power as purchased through a meter with the cost of coal consumed in running a small steam engine, unless the attendant advantages of electric power be also referred to. Many will remember the figures published in reference to the substitution of electric power in the Government Printing Office at Washington, the figures being very complete, and available to anyone. As I remember, the cost of maintaining that institution is about $11,000 daily; with the substitution of electric power it was expected that approximately $30,000 would be saved annually, which would represent a very good return upon the cost of making the change. They found, however, that in addition to this the output of the establishment was increased about 11 per cent, without any corresponding increase in operating costs other than the investment; so the saving, or value of the change, instead of being $30,000 annually, as was first hoped, became more nearly $300,000. Another result was the reduction of 55 per cent in the number of absentees on account of illness during the first year. This probably resulted from the relative quietness of the establishment with the removal of the belts and shafting formerly required for the transmission of power.

DR. PERRINE: I would mention a case where a 400-hp motor was put in a flour mill and the capacity of the flour mill was raised 20 per cent. This was accomplished without any change of machinery, and was simply due to a greater uniformity in running the roller, enabling the millers to adjust the rollers more closely, and increasing the output of the mill 20 per cent by reason of uniformity in speed.

### *7.—What is the best means to reduce breakage of inner globes on series inclosed-arc lighting?*

A large proportion of the inner-globe breakage is caused in handling the globes; in washing them, taking them to the lamp, placing them in the lamp and removing the old globe. Our experience is that it is best to clean the inner globes at the station, replacing the dirty globes with clean ones at each trim.

The globes are carried to and from the lamp in baskets arranged with partitions for supporting the globes, somewhat similar to egg crates, excepting that there is only one layer of globes.

We use at the station a washing machine made by A. P. Peterson, of Rockford, Ill., which consists essentially of a spindle driven at high speed and carrying at one end a bundle of loose bristles. A brass tube with end flared to receive the mouth of the inner globe normally covers the brush, but is arranged to slide back when it is desired to clean a globe, thus exposing the brush, which is thrown out radially by centrifugal force against the inner walls of the globe. This machine is free from many of the objections to the ordinary type of bottle-washing machines frequently used for this purpose. Tanks with flowing water for rinsing the globes are conveniently arranged with racks above for drying them.

Great care is taken to cut the lower carbons to the length that has been found best adapted to the particular lamp used. This is never more than five and three-quarters nor less than five and one-half inches. With longer lower carbons there is incessant trouble from inner globes softening at the upper portion.

There is a vast difference in quality and workmanship among the various makes of inner globes on the market, some averaging as much as 25 per cent longer life than others, which incidentally, of course, affects the life of the carbon. The principal fault is imperfectly ground surfaces, or ends not parallel in globes that are open top and bottom.

Another fruitful source of trouble with inner globes is unduly high voltage at the lamp terminals. We provide against this by frequent tests of the various circuits during each night's run. Knowing the loss in the wire of each circuit, we are enabled to keep the average voltage per lamp very uniform. This is, of course, supplemented by individual tests on lamps that are reported by the inspector as burning long arcs. With certain makes of lamps that increase considerably in voltage on account of the heating of the shunt coil, we reduce the current one-tenth of an ampere or so every hour for two or three hours, or until the lamps attain their constant maximum temperature as indicated by the circuit voltage.

H. T. HARTMAN,
Philadelphia, Pa.

Careful attention to the adjustment of the lamps and a system of cleaning at the station or other convenient place after each trimming, providing a basket or box with separate compartments for each globe for carrying same.

W. T. OVIATT,
Bridgeport, Conn.

It seems to me that the principal thing to do is to get the glass makers to put a better quality of glass in the globes and to make the glass thicker at the ends; also to be sure that the ends are smooth and perpendicular to the axis of the globe.

F. ELLWOOD SMITH,
Somerville, Mass.

(A) A greater amount of care should be exercised by trimmers in replacing carbons and renewing inner globes.

(B) When installing the series alternating system, care should be exercised that the primary voltage is not too high, and that both the primary voltage and the frequency are the same as that for which the transformers were made.

(C) The time has gone by when it was of advantage for central stations to experiment with leaving off the outer globes of lamps. Experience has shown that the outer globe protects the inner from breakage, especially during cold weather.

(D) The glass manufacturers should take a keener interest in the testing and inspecting of inner globes. It is a fair question to ask if they employ an electrician with their inner globe department. Do the glass manufacturers offer any different or more durable inner globe for the 7.5-ampere lamp than they do for the 4.4-ampere lamp? One lamp consumes 285 watts and the other nearly 500 watts. The glass manufacturers should be more aggressive on the subject of testing and inspecting inner globes before shipment, and should assume greater responsibility regarding their operation.

H. W. Hillman,
Schenectady, N. Y.

The cause of excessive breakage of inner bulbs on series inclosed-arc lamps is due to lamps drawing too long an arc. When this occurs, the arc flame curves out and either burns a hole in the bulb or causes it to warp so that it is of no further use. I should say that the best means to reduce breakage would be to perfect the mechanism of lamps so that it would be an absolute certainty that lamps would feed or cut at a given point; say, about 90 volts across the arc.

P. J. Smith,
Chicago, Ill.

Excessive breakage of inner globes in inclosed-arc lamps may be attributed to one or several of the following causes:

(1) Inferior quality, uneven thickness of glass, and poor workmanship.

(2) Improper design of inner globe; too heavy gas valve or cap, or non-flexible support for globe.

(3) Too long or too short carbons.

(4) Careless trimming, cleaning and handling of inner globes.

The first cause of inner-globe breakage is entirely dependent upon the experience of the globe manufacturer and the quality of the globe. A large percentage of the total breakage is due to this cause, therefore it is not always advisable to use the cheapest globe. An examination of several lots of the same style of inner globes manufactured by different glass companies will prove that some globes are very light, others medium, and some heavy. The very light globes are not desirable, on account of easy breaking and chipping while they are being handled or cleaned, and "buckling" from the heat of a normal arc. The heavy inner globes should not be used, as they do not expand evenly and quickly when the arc is struck; for this reason they often crack and thus become quite useless. The medium-weight inner globe, having about one-thirty-second to three-sixty-fourths inch wall, is the one to be recommended, as it possesses sufficient mechanical strength and will expand or contract evenly and rapidly without cracking. The glass company that fills your regular orders with inner globes that are uniform in weight, size, and thickness of wall, should have your favorable consideration, even at an advanced price.

The second cause of inner-globe breakage depends entirely upon the design of the inner globe and lamp. The breakage due to these defects is very small in all modern lamps.

The third and fourth causes of breakage are under the control of your arc-lamp inspector and trimmer. As the breakage of globes due to improper trimming of lamps and handling and cleaning of inner globes is often 50 per cent or more of the total breakage, it is of the greatest importance that a practical system for gauging and cutting carbons, cleaning and handling inner globes, and trimming the lamps, be adopted and rigidly enforced. Experience has proved that the trimmer should not have to cut or gauge carbons or clean inner globes while out trimming lamps, but carbons of proper length and diameter and clean inner globes should be carried by him and be simply exchanged for the burned carbons and dirty inner globes on the lamps. These burned carbons and dirty globes should be brought back to the station, or other suitable place, where the carbons can be cut to the proper length and the globes cleaned. When this system of trimming and cleaning is employed, the breakage is reduced to a minimum; and the time required for trimming is reduced, provided the proper methods for conveying and cleaning the globes are employed. You can purchase suitable baskets in which to carry globes and carbons. Small water motors, to which are attached revolving brushes, are now for sale. The proper methods for trimming and cleaning arc lamps and globes will materially increase the efficiency of your system, and the cost of trimming and breakage will be much reduced.

J. H. HALLBERG,  
New York City.

***8.**—To what extent are Nernst lamps displacing arc lamps?*

This question is answered in connection with questions Nos. 21, 22, 23, 24 and 25.

***9.**—How may street arc lamps be best protected from the public's tendency to destroy them?*

Have an ordinance passed by the city or town council, with penalty, and encourage policemen to enforce it. Detail special detective. Our borough treasury was enriched in that way until the practice stopped.

CHAS. E. SCOTT,
Bristol, Pa.

We have asked the assistance of the policemen and the school teachers with good results. We have also posted signs on our poles offering a reward of $5.00 for evidence leading to the conviction of persons injuring our property.

F. ELLWOOD SMITH,
Somerville, Mass.

After having considerable trouble in this line we tried several different methods to prevent such damages and found that the posting of large cards offering a reward for evidence that would lead to the conviction of anyone injuring our property was the most effective means of stopping such work; although this plan has not entirely eliminated the trouble.

E. W. MATHER,
Portland, Me.

By offering a reward large enough to be an incentive to the public to give information that would cause the conviction of those causing the damage, and posting notice to that effect on the lamp poles.

W. T. OVIATT,
Bridgeport, Conn.

Make them pay for the damage, if caught. We find the globes suffer most from rocks thrown by boys. When sufficient evidence can be obtained, present a bill for the globe to the boy's parents. We have found this method satisfactory.

CHAS. H. PETERS,
Durango, Col.

***10.**—What are the most vital considerations in the selection of a constant-current transformer or regulator for series alternating-current arc lighting?*

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In my estimation, a 75-light, constant-current transformer in two circuits, or a 50-light transformer in one circuit, is the largest that should be used in the majority of central stations; as, from our experience, the trouble with the high potential is one of the most vital things with which we have to contend.

F. L. SARGENT,
Malden, Mass.

High insulation; rapid and sensitive action; freedom from hunting; minimum impedance compatible with safety in regulation.

W. E. GOLDSBOROUGH,
Lafayette, Ind.

The most vital considerations in the selection of constant-current transformers or regulators for series alternating arc lighting are: First, simplicity and reliability of the apparatus; second, absolute insulation between the generator winding and the arc circuit; third, close regulation, and ability to take care of sudden changes in load; fourth, the lack of attention necessary during operation. E. J. BECHTEL,

Toledo, O.

Series alternating arc-lighting systems should have a high power factor at all loads that will be put on the system. The arc-lighting system should, of itself or by means of a separate transformer, be isolated from the remainder of the general distribution system. The design of the regulator or transformer should be such that no damage would result even in cases of short circuit on the arc-light circuit that it regulates.

P. JUNKERSFELD,

Chicago, Ill.

*First*—Reliability of operation
*Second*—Steadiness of operation
*Third*—Accuracy of operation
*Fourth*—Power factor
*Fifth*—Efficiency
*Sixth*—Flexibility as regards large changes in the number of lights used with small differences in power factor and efficiency. J. H. PERKINS,

Youngstown, O.

### 11.—*What is the relative efficiency of open and inclosed-arc lighting?*

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[It is quite impossible to give an answer to any of the questions propounded—11, 14, 15, 16, 17, 18, 19 and 20—without knowing all the conditions. In each case the answer will necessarily be subject to the particular conditions that exist, and which are not embodied in the question. Again, the answers in some cases—for examples Nos. 18 and 19—will depend largely upon questions of policy. L. B. MARKS.]

Basing the comparison on watts per mean spherical candle power, the open arc is approximately 25 per cent more efficient than the direct-current inclosed arc and 40 per cent more efficient than the alternating-current inclosed arc. Taking the open arc with clear glass globe and the inclosed arc with opalescent inner and clear outer globe, the following average values may be given:

Open arc, 1.5 watts per mean spherical candle power.

Inclosed arc, d. c., 2 watts per mean spherical candle power.

Inclosed arc, a. c., 2.5 watts per mean spherical candle power.

LOUIS B. MARKS,
New York City.

The efficiency of inclosed-arc lighting is much higher than that of open-arc lighting, as a general rule, for the following reasons:

*First*—The light is steadier.

*Second*—There is better diffusion of light along the street surfaces, especially if an opal inner globe of moderate density is used in the inclosed-arc lamp.

*Third*—The absence of marked shadows of the carbons or lamp parts when inclosed-arc lamps are used.

*Fourth*--There is plenty of light under an inclosed-arc lamp and there is more light half way between the lamps when inclosed lamps are used than when open lamps are used, and the expenditure of energy is the same.

*Fifth*—The cost of maintenance is so much less with inclosed than with open-arc lamps, that the former have this great additional advantage.

W. E. GOLDSBOROUGH,
Lafayette, Ind.

The relative efficiency of open and inclosed-arc lighting depends greatly upon local conditions. Under the conditions in Toledo, we should save $10 per lamp by using alternating inclosed arcs instead of the present open arcs with Wood 80-light and 125-light generators belted to line shaft.

E. J. BECHTEL,
Toledo, O.

***12.**—Should we use large lamp units for street lighting, or use smaller lamps, placing them nearer to one another?*

This, of course, is different in every locality. It depends largely upon whether the district is entirely residential or is a large manufacturing centre. In the case of a residential city, with a great deal of foliage on the streets, small lamps are much to be preferred, in my estimation, and would give better lighting service at less cost than large arc-lamp units placed farther apart. In our plant here we have 3,000 25-cp series incandescent lamps throughout our residential

district, running on constant-current transformers, and about 325 6.6-ampere inclosed-arc lamps throughout the business district.
F. L. SARGENT,
Malden, Mass.

Where the cost of installation is a matter of secondary importance, small lamp units placed relatively near together give better results as regards illumination than do large lamp units placed at relatively great distances apart. The power consumption per foot length on the street is the same in both cases.

W. E. GOLDSBOROUGH,
Lafayette, Ind.

The question of the use of large arc-lamp units for street lighting, or the use of smaller lamps, placing them nearer to each other, depends greatly upon local conditions. First; the present installation must be considered. Next, the general plan or layout of the city or town to be lighted. After that, the question of the system previously used, whether large or small lamps; and finally, the number of shade trees, etc.

The use of small lamps placed near together gives better distribution of light per kilowatt of current consumed. If, however, the 9-6-ampere open-arc lamps have been previously used, the light given by lamps smaller than 7.5-ampere alternating current will be noticeably less to the average person, which might lead to complaint, according to the disposition of the people. A very interesting paper on this subject was read before the Ohio Electric Light Association at its convention in August, 1901, by Mr. W. D'A. Ryan.

E. J. BECHTEL,
Toledo, O.

*13.—What effect would distance between arc lamps have upon the selection of open or inclosed lamps for street lighting?*

Open lamps can be used to better advantage than inclosed lamps where great brilliancy of illumination over a given area is desired, for the reason that the brilliant circles of light beneath the open-arc lamps will overlap and commingle in such a way as to eliminate the effect of carbon and lamp-part shadows and the flickering of individual lamps, with the net result of obtaining a greater total candle-foot illumination per unit of area for the same expenditure of energy with open than with inclosed-arc lamps. If, however, lamps are placed over 75 feet apart, the inclosed lamps will give the more pleasing results.

W. E. GOLDSBOROUGH,
Lafayette, Ind.

If arc lamps can be placed within 100 feet of each other, I would recommend the use of open-arc lamps; if they must be placed to exceed 600 feet from each other, I would unquestionably recommend the use of inclosed-arc lamps, as the latter will give much more satisfactory illumination between lamps, owing to the fact that a larger proportion of the light is given off between zero and 30 degrees below a horizontal line. Between 100 and 600 feet, decision would depend entirely upon local conditions. ANONYMOUS.

In my opinion, inclosed-arc lamps are preferable for street lighting under all conditions of distance between lamps; especially so when the distance is great. The inclosed-arc lamps not only give better illumination at distances over 100 feet from the lamp, but give much steadier light and have not the objectionable glare or high lights within 50 feet of the lamp.

E. J. BECHTEL,
Toledo, O.

*14.—What is the relative cost of maintenance of a 6.6-ampere, alternating-current, series lamp and a 7.5-ampere lamp of same type, especially so far as life of carbons and breakage of inner globes are concerned?*

(A) Breakage of inner globes may easily be 20 to 30 per cent greater with 7.5-ampere current. If an aggressive policy on the part of central-station managers should be put into effect, as suggested in the answer to question No. 7, referred to above, the problem on this point would be solved.

(B) Regarding life of carbons, a 7.5-ampere, alternating-current lamp has a life, in actual experience, of 10 to 15 per cent less than a 6.6-ampere lamp of the same type. There are lamps on the market of the 7.5-ampere type, using 12-inch carbons, that would give a life of one week during the winter season, operating, say, 14 hours a day. The cost of maintenance would then be slightly higher for carbons only, the cost of labor being the same as for the 6.6-ampere lamp.

H. W. HILLMAN,
Schenectady, N. Y.

The relative cost of maintenance (trimming, carbons, globes and repairs) of a 7.5-ampere series alternating-current lamp would be from 15 to 20 per cent more than that of a 6.6-ampere lamp.

LOUIS B. MARKS,
New York City.

### *15.—What is the relative cost of trimming and maintenance of open and inclosed-arc lamps?*

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For all-night service the cost of carbons, trimming and globes is about $10 more per lamp per year for the open arc than for the inclosed. For short-hour service the relative cost of maintenance of the inclosed type is, roughly, about one-third that of the open.

LOUIS B. MARKS,
New York City.

The cost for trimming and maintaining open-arc lamps is about 60 per cent greater than for inclosed-arc lamps.

P. J. SMITH,
Chicago, Ill.

DISCUSSION

THE PRESIDENT: Mr. Marks states that you can save $10 a year.

MR. MARKS: I think that is about the average saving that central-station men report. I have taken the statistics from a large number of central stations, and the average saving per lamp per year in street service is approximately $10.

THE PRESIDENT: What do you say the cost is for trimming open-arc lamps?

MR. MARKS: That depends upon conditions and upon how many arc lamps a trimmer can take care of. In some cities a trimmer will take care of 100 lamps, and that number, at $2.50 per day, will average two and one-half cents per lamp; but in other cities the figures vary considerably from this. The same thing is true of inclosed-arc lamps. In some cities the trimmers will trim 75 of these in a day, making the cost of trimming thirty-three and one-third per cent more per lamp than the cost of trimming the open-arc lamp; but taking all the figures together, and averaging them up, I think the figure given above is a fair one, and that the saving accruing from the use of the inclosed-arc lamp is, in round figures, $10 per lamp per year.

THE PRESIDENT: I am trying to get the gross amount by which you get the difference. You subtract one amount from the other, which leaves $10. What is the gross amount?

MR. MARKS: I think the average figures would be $6.00 and $16, giving a difference of $10.

MR. BERTRAND (Peoria, Ill.): Our cost per lamp of operating 600 series, direct-current, open arcs, as compared with 25 series, alternating-current, inclosed-arc lamps, shows a difference of about $7.00 to $8.00 per lamp per year in favor of the inclosed-arc lamp. The cost of operating the latter is in the neighborhood of $6.00 to $7.00.

MR. ISAAC B. SMITH: I think the gentlemen do not take into consideration the systems in the different towns. The tendency of the day is to light up the country districts with a long file of lamps, which causes the trimmer to retrace his steps. Our alternating lamps are in a position that is more favorable to their being trimmed than the average alternating lamps, and I should judge, to make a rough figure, that our saving is nearer $12 than $10.

MR. MANWARING: In Philadelphia, we pay our trimmers on the piece-work system, at the rate of two cents per lamp for trimming, and the average trimmer takes care of 100 to 125 lamps per day, six days in the week; on Sunday the number diminishes according to the number of six-night commercial lamps. By this system our saving on Sunday trimming more than balances the increased expense of week days, and we show a saving over our previous method of paying $2.00 per day, straight, and the men are better satisfied. By this system it costs $7.30 per annum for trimming street lights.

***16.**—What advantages has the series system of inclosed-arc lighting for street circuits over the multiple system, other than the saving of wire in making the circuit and the doing away with independent transformers on the line?*

Having been asked to answer this question, I should say that the inherent advantages of any one system over the other are so modified by conditions, and the disadvantages may be so changed by modified apparatus, that to state these advantages without any discussion seems like offering oneself as a target for the other party to throw at. The reasons that induced the company with which I am connected to adopt the series system, are:

*First*—Street lighting in the past being almost altogether by the series open-arc system, a change to a series system required no change in wires and a minimum first cost.

*Second*—Because the system, as a whole and in its parts, is of higher efficiency.

*Third*—Because the regulation is so perfect and automatic as to require almost no attention from the station employee.

*Fourth*—Because of a more direct control of the system by the station attendant, who, by pilot lamp or other device, is notified of trouble on the line, and will immediately turn off the current in case a wire that might endanger life or property is down in the street.

*Fifth*—Because of the greater stability of the arc and the double circuit (series and shunt) insuring a greater certainty of operation.

*Sixth*—Because by running the outgoing wire through a street or streets and the return wire through other streets we get a shorter line, fewer wires per street, and reduced possibility of short circuits, so called.

*Seventh*—Because in case of short circuits it seldom happens that all the lamps are cut out, and the point at which the short circuit occurs is indicated to a certainty by the dividing line of lighted and unlighted lamps on the street; while with a multiple system either the short circuit must be burned off or the circuit be shut down without any indication of where to look for trouble.

*Eighth*—A grounded circuit does not ground the whole system, as it would do if there were no transformers or dynamos between the line and the 'bus-bars.

*Ninth*—Because after having determined upon a satisfactory unit there would be no temptation to increase the number of lamps per circuit to an excessive degree and thus endanger the lighting of a very extensive area by trouble to lines or apparatus.

*Tenth*—Because a satisfactory illuminating power having been determined upon, we could not be called upon by every person thus inclined to change it and thus complicate the system, add to the number of spare lamps and parts it would be necessary to have on hand, affording an opportunity for ignorance or accident to place a lamp of inferior candle power in a prominent square to cause friction with city authority or remarks by citizens.

*Eleventh*—Because all lamps must be turned on at the station and no extra attendance is required to switch lamps on and off.

*Twelfth*—Because the most important advantages claimed for the multiple system may be nearly, if not quite, attained by the series system by a judicious attention to details of installation without surrendering any of the advantages of the series system.

WALTER R. EATON,
Cambridge, Mass.

(A) A distinct advantage of the series system is its convenient method of controlling; all lamps are started almost simultaneously.

(B) An advantage of this method is the nominal expense to the station.

(C) Another advantage is to the city; having all lamps started promptly and at same time.

(D) There is no universally satisfactory system for controlling multiple lamps. H. W. HILLMAN,
Schenectady, N. Y.

I do not believe that the series system of arc lighting has an all-round advantage over the multiple system. I believe that the multiple system has a great advantage over the series system, and note the following reasons: In the multiple system the power factor is practically constant, regardless of the load, therefore making the generator capacity dependent on the number of arc lamps burning rather than on the number and size of constant-current transformers connected to the generator. The constant-current transformer is at its best power factor at full load, and I do not believe that this power factor at full load can be made as high as the power factor of the multiple system, which is the power factor of one lamp. The power factor of the constant-current transformer drops off rapidly as the load is decreased, and in our own case I can not see how we could operate all the constant-current transformers necessary to do our arc-lighting business at their best power factor all of the time. One or two might be fully loaded; the third would have to take what lamps were left and operate much under load. Again, if we load up all the constant-current transformers we have no room left on our arc circuits to add more lamps as the city may desire.

*Second*—I would call your attention to the very simple and inexpensive switchboard apparatus necessary for the operation of the multiple system, and the saving of room in the station that would otherwise be occupied by constant-current devices.

*Third*—I believe there is less danger of interruption to the service due to accidents to transformers, to badly acting lamps, to open circuits, to grounds in fixtures, etc.

*Fourth*—As the lamps in the multiple system are connected to secondary circuits, the liability of grounds and open circuits in the lamps is reduced to an extent equal to the ratio between the voltages between the two systems.

*Fifth*—The problem of insulation of lines becomes a much more expensive and important factor in the series system at 7,000 or 8,000 volts than it would be in the multiple system at 2,200 or 2,400 volts.

*Sixth*—In the multiple system, arc lamps of various candle powers and power consumption may be used, making it possible to give the city any candle power of lamp that may be desired in any locality.

*Seventh*—Coming to the question of a multiple lamp, I find that the multiple lamp is cheaper and of simpler mechanism than the series lamp; and right here is a point on the flexibility of the multiple system, in that if the multiple lamp is discontinued for use on the street, it can be used inside of stores, officies and buildings, and the station using this system will be obliged to carry but one kind of lamp—the multiple lamp—and one kind of supply and repair parts for same. There is one point about the lamp, and that is the vital part of the multiple system for its best operation, and on that point I hope to have some light shed by some of the arc-lamp people present; it concerns the matter of the starting current required by the lamp at the instant of closing the switch. I have tried recently five prominent makes of multiple alternating-current lamps of the 6.6-ampere style, and the starting current required varied from their normal rating at 6.6 amperes up as high as 18 amperes. Now, you will see at once what will happen if you take a circuit of 50 multiple lamps on the city streets and expect to start the same 50 lamps by closing the main switch at the station. Such an operation would be followed by the instant operation of circuit breakers and probable blowing of fuses and overloading the generator. Another point with most of these five lamps that I tried was that on releasing the clutch, or should the carbons come together accidentally, the lamp itself would burn out. So far as I have gone with some little experimenting, I have not been able to buy a multiple alternating-current arc lamp whose starting or picking up current is kept down to at or near the burning current of the lamp, and it seems to me that it must be one of the requirements of the multiple system that the starting current required by the lamps shall exceed by only a very small margin the normal burning current of the lamp; and I hope to see some lamp manufacturer bringing out—if they have not already done so—a lamp with these features.

In conclusion, I would say that if we have a lamp with the above-mentioned features, I see no reason why a station now having arc circuits composed of two No. 4 wires or two No. 6 wires, as in the case of our own, may not install the multiple system of arc lighting at a much greater advantage to itself and the public than it could install the series system with a constant-current transformer. The two No. 6 wires or the two No. 4 wires already strung for the old open-arc system are amply large for 50-light circuits on the multiple system, as the loss on primary amperes would be practically negligible, and this loss is being done away with the further you get from the station, because the number of lamps is diminishing.

Welles E. Holmes,
Newton, Mass.

An advantage (not mentioned in the question) of the series alternating over the multiple alternating-current system, lies in the steady light given by lamps of the former. All arcs are steadier when supplied by constant current than when by constant potential. Another advantage is in the higher power factor of the series alternating-current system.

Louis B. Marks,
New York City.

The series system of inclosed-arc lighting has the additional advantage that it lends itself very well to supplying customers desiring a flat rate who would not accept multiple lamps on a meter basis. It is also more efficient than the multiple system.

P. JUNKERSFELD,
Chicago, Ill.

*17.—When incandescent lamps are displaced with incandescent arc lamps, does it curtail or increase the station's income?*

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When incandescent lamps are displaced with incandescent arc lamps, I should feel as if it curtailed the station income, on account of a much poorer power factor and increased cost of maintenance.

F. L. SARGENT,
Malden, Mass.

When incandescent lamps used for ordinary illumination are displaced with arc lamps, it has been our experience that the customer was more willing to pay an increased bill for the superior service, as he felt that he was receiving considerably more for the same money. The result of this was that a more kindly feeling was aroused among all our customers using arc lamps than among those using incandescent lamps, and whatever method is used to create such a situation will increase the station's income.

C. R. MAUNSELL,
Topeka, Kan.

As a general proposition, I am of the opinion that when incandescent lamps are displaced with incandescent arc lamps, the station's income is invariably increased.

LOUIS B. MARKS,
New York City.

To displace incandescent lamps with incandescent arc lamps may not, in individual cases, decrease the station's income, but in general it must decrease the station's income, because the income per 1,000 cp-hours is less with arc lamps than with incandescent lamps, and you can not expect a consumer to pay you more money on an equipment that is capable of yielding much higher efficiency simply on account of this fact. ANONYMOUS.

I think there is no question but that the station's income will be increased by substituting arcs for incandescents in all cases where arc light is desirable for general illumination. However, the question of illumination is one that can be divided into two general classes; general and direct. Each class has its own relations to the requirements for quantity and quality, but, so far as methods as to choice of illuminants are concerned, there is an important distinction between light intended to be generally diffused and light intended to facilitate operation at particular points.

Take, for illustration, a store with high ceilings, such as a clothing store, the goods being dark and absorbing considerable light—and try to furnish satisfactory light with incandescents. The principal objection that will be found will be that the general illumination is unsatisfactory. The result is an old, old story. The customer will say that the service is unsatisfactory. The store is poorly lighted. He finds it difficult to do business, and insists upon some other form of illumination which will give him a larger volume of light, and, if he be a large consumer, unless proper light can be furnished he will probably bend his energies in the direction of furnishing his own light, even at a higher cost. I think the fact is generally recognized by merchants that light is one of the best means of advertising; but in spending money for advertising, as in everything else, they want as much for their money as they can get.

The only way in which business can be built up and developed on a solid basis is by furnishing satisfactory service and having customers satisfied. It seems to me, therefore, that the question of revenue for various forms of lighting is a secondary consideration:

*First*—Furnish light suited to the requirements.

*Second*—Make a rate that will be proper compensation for the service.

The same light that was used 10 years ago will not answer the requirements of to-day, because the light standard has changed. Method and form have changed and volume has increased.

Taking the question as it would apply generally in small stores, saloons, warehouses, etc., as I have stated above, I do not think there is a question but that the station's income will be increased by substituting arcs for incandescents. Most merchants who have succeeded in business are endowed with a spirit of economy, and if they use incandescent lights they will not turn them on until they are actually needed. That may mean that there are four or five lights burning and the place looks dark and three or four more are turned on later; still, it does not present a cheerful appearance and is not well lighted, whereas if an arc were installed the consumption would be equivalent to 11 16-cp incandescents for direct current, and the place would present a cheerful appearance because it would be well lighted, and the merchant would not complain about the size of the bill, because he appreciates that good light and plenty of it helps his business.

H. J. GILLE,
St. Paul, Minn.

If the customer is satisfied with the same amount of candle power, and maintains the same amount, and does not burn his arc lamps longer or shorter hours than the incandescent, it will curtail the station's income; but it is a very difficult question to answer from experience, as the inclination to change generally indicates dissatisfaction on the part of the customer with his lighting effects, the quality of illumination, or the bills, and the particular motive prompting the change will therefore affect the quantity of current consumed, making more in some instances and less in others.

JOHN F. GILCHRIST,
Chicago, Ill.

For the lighting of a given space the revenue derived by the station will in most cases be much less for arc lamps than for incandescents. This decrease is in most cases only temporary, however, and does not last for a long time, as the increased satisfaction given by the arc lighting, where properly installed, encourages the consumer to use more light than he previously did when he finds that it costs him no more. The arc lighting, properly installed, becomes a good advertisement for the station, and when advocated by a satisfied customer will usually bring in enough new business to offset any temporary reduction in revenue.

P. G. GOSSLER,
Montreal.

### 18.—*Should parallel arc lamps be purchased by the consumer, or be furnished by the station, either free or at a fixed rental?*

Replying to your question No. 17, regarding the ownership of parallel arc lamps, I would say that all our experience has been in favor of ownership by the lighting company.

No matter how uniform your voltage may be, if a poor lamp is installed, poor carbons are used, or the lamp is carelessly trimmed or is allowed to get into bad condition, the service will be unsatisfactory. You will never be able to excuse or explain the poor results to the customer who owns his arc lamps, or to his friends to whom he tells his troubles. The only thing you can do is to fix his arc lamp up for him and properly retrim it with first-class carbons. In a short time the conditions are as bad as ever. In other words, you have practically the same amount of trouble and responsibility when the customer owns the lamp as when it is owned by the station, while in the latter case you are able to determine the style and character of lamp and quality of carbons to be used, and to see that it gets skilled attention whenever it needs it. Under such circumstances there is no excuse for poor results.

With regard to renting constant potential arc lamps, I would say that we use them principally for competition with Welsbach or other cheap light, and so far from being able to exact a rental we are frequently obliged to cut our standard rates for current. Of course, conditions differ in different cities, but we have plants in six states and find the situations practically the same in all. H. T. HARTMAN,

Philadelphia, Pa.

I am in favor of the station's furnishing multiple arc lamps to consumers free, but it should provide for the increased cost over the watt equivalent in incandescent lamps, due to low power factor, by a two-rate system in which allowance is made for such increased cost. W. J. GREEN,
Cedar Rapids, Ia.

I am strongly in favor of the station's supplying parallel arc lamps. The station should also trim and care for the lamps. The consumer could be charged a certain extra fixed sum per month to apply on account of payment for lamps.

LOUIS B. MARKS,
New York City.

If the consumer can be induced to purchase parallel arc lamps, the company can afford to give a material reduction in rate, as the purchase of any equipment by the consumer is the best guarantee of a continued contract for service. The purchase of lamps by the consumer is also a very excellent excuse for making a special rate for some desirable customers where otherwise it would create a very bad feeling if the special rate were known to other users. In the majority of cases the company should supply arc lamps at a fixed rental or on a minimum charge per lamp. We feel that the fixed rental would be the better plan, although we have established the minimum rate.

C. R. MAUNSELL,
Topeka, Kan.

I see no reason why inclosed-arc lamps should not be purchased by the consumer under all circumstances, thus avoiding the risks incident to the station's having its property distributed all over the city and being entrusted to the hands of all classes of customers, destruction by fire, lamps getting broken, etc.

There is no more reason why electric-light companies should furnish arc lamps free than why gas companies should furnish gas ranges or electric-light companies furnish fixtures, wiring, etc. However, I feel that the station should take care of the lamps; that is to say, furnish inner globes, trim, and do small repairs. This practically takes the place of furnishing incandescent-lamp renewals *gratis*, as I estimate that the expense of trimming inclosed-arc lamps is practically the same as furnishing incandescent-lamp renewals. The only question that might arise is, How can this be done properly, so as to avoid getting on the system all the different makes of arc lamps on the market for which supply and repair parts would have to be carried in stock by the station? To this I should reply, that the station specify lamps for which repair parts are carried in stock, and any customer buying lamps of other makes must furnish the globes and repair parts himself, the station simply trimming them; and, further, the station should agree, when selling arc lamps to consumers, to take them off their hands should they decide to discontinue the use of arc lamps and desire to dispose of them; that is to say, allow the cost price, less a depreciation of 10 per cent per annum. These second-hand lamps could in turn be disposed of to prospective customers at the price allowed, plus the cost of putting same in good condition; that is to say, the lamp should be thoroughly overhauled before being put back in service; in other words, the station should act as a clearing house. Take this, for illustration: A customer buys a lamp for $15. At the end of one year he discontinues business and desires to dispose of the lamp; he has an agreement with the station to take the lamp off his hands, provided the lamp is in good condition, less a depreciation of 10 per cent.

H. J. GILLE,
St. Paul, Minn.

In the opinion of the writer, they should be furnished free, so far as any specific charge for the rental of the lamp itself is concerned.

JOHN F. GILCHRIST,
Chicago, Ill.

**19.**—*How may rates be so adjusted as to compensate for the low power factor of alternating-current multiple lamps, which require a larger investment for generating and transformer equipment and a greater core loss?*

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By using a combination demand and meter rate, the demand based on apparent energy and meter to register true energy.

H. H. SCOTT,
Lincoln, Neb.

Rates may be so adjusted as to compensate for the low power factor of alternating-current multiple lamps, by arranging an equitable sliding scale of discounts for such current service.

LOUIS B. MARKS,
New York City.

I believe that a charge should be made for "readiness to serve" a consumer, and that, in figuring the cost of readiness to serve, volt-amperes of alternating-current arc lamps should be used as representing the demand on which they should pay, and the true energy supplied should represent the charge for current used.

ANONYMOUS.

**20.**—*What is the relative cost of trimming and maintaining inclosed-arc lamps as compared with furnishing free renewals of glow lamps?*

It costs about four or five times as much to trim and maintain inclosed-arc lamps as it does to furnish free renewals of glow lamps.

LOUIS B. MARKS,
New York City.

One trimmer can conveniently take care of approximately 300 commercial arc lamps. He can, of course, trim a great many more, but will be compelled to neglect a great many lamps that need attention.

Assuming an average burning of three hours per day or approximately 45 kw-hours per month for each lamp, the life of one trim being 100 hours, the life of the inner globe 600 hours, the 300 lamps would consume approximately 13,500 kw-hours, 270 carbons and 45 inner globes per month. The expense, not including repairs therefor, would be

| | | |
|---|---|---|
| 1 | trimmer.................... | $55.00 |
| 270 | carbons at 3 cents each..... | 8.10 |
| 45 | globes at 10 cents each..... | 4.50 |
| | Total cost............... | $67.60 |

making the total cost approximately five mills per kw-hour.

Assuming the life of an incandescent lamp to be 600 hours, consuming 50 watts or 30 kw-hours during its useful life, lamp costs 15 cents in the store house, or equal to five mills per kw-hour. This cost does not include the delivery of lamp renewals to customers, which I think is generally customary, but figuring on a store-house basis for incandescent lamps and trimming arc lamps, there is, I think, very little difference in the cost. I have assumed that the customer owns the arc lamps.

H. J. GILLE,
St. Paul, Minn.

*21.—What results have been obtained from the use of Nernst lamps?*

Thirty-two 106-volt Nernst lamps, placed in the office and dining-room of a hotel, have given splendid satisfaction so far as light is concerned. The life of the glowers, however, has been short, averaging less than 100 hours. A recording voltmeter shows even regulation at proper electromotive force.

W. J. GREENE,
Cedar Rapids, Ia.

For one year we have operated in our general offices at 510 West Twenty-third street, New York, for the purpose of general illumination, 48 single-glower, three three-glower and six six-glower Nernst lamps (a total of 93 glowers) on a circuit of nominal 216 volts, alternating current. Records show that at times the voltage has been as high as 242 and as low as 194, with an average variation of approximately eight per cent; that is, four per cent above and four below. The character of the light has been all that could be desired. Some little trouble was experienced in the cut-out of the single-glower lamps shortly after installation. These were repaired and since then have operated entirely satisfactorily. In the three-glower lamps a slight humming was noticed when first installed, but that was remedied and there has been no trouble since. Records of the number of glowers replaced were not kept previously to September 1, 1901. From this date to April 18th, but 68 new glowers had been put in. In one instance, at least, in a single-glower lamp there has been but one replacement during the year; this was in a lamp that has operated satisfactorily since the beginning, burning an average of four hours per day, with the glower now apparently in good condition. The care of the lamps has been entrusted to a boy about 16 years old, whose duties have been to light the lamps in the morning and make replacements of burned-out glowers. It is interesting to note that apparently the best service is received from lamps with more than one glower; the cause for this the Nernst Company can probably give.

As stated above, shortly after the lamps were installed, in May, 1901, some few mechanical defects were noted. We are not surprised at the few defects noted in these earlier lamps, as such might naturally be expected while the lamp was in a more or less experimental stage. These troubles have, however, been satisfactorily remedied, and the lamps have, without exception, operated perfectly satisfactorily ever since.

We understand that the price of Nernst lamps has been regarded as rather high, but this would be natural in view of the presumably large expense involved in the experimentation necessary to bring the lamp to its present successful form. It would be natural to expect, now that the preliminary work is practically over, that the price of lamps will be reduced, so that there can be no reasonable ground for criticism on this score from now on.

In short, our experience with the Nernst lamp has been such as to demonstrate that in its present shape it is a commercial success. As to the extent to which these lamps are being used, the Nernst company can probably give more reliable data. We have observed them in a great many places, and the replies to our inquiries as to their successful operation have always been in the affirmative. The matter of renewals is a very simple one, which any intelligent office boy can successfully carry out. FRANK S. SMITH,
New York City.

We have felt the necessity for some time for a lamp to fill the gap between the ordinary cluster and the 500-watt inclosed-arc lamp. In quite a number of places the cluster would not give sufficient light, while the 500-watt lamp would give more light than was really necessary; and in other cases one arc lamp would not give sufficient light and two lamps, too much; besides, the cost of current to the consumer in both cases would be more than circumstances would warrant. The 350-watt inclosed-arc lamp was tried, but with indifferent success, there being little difference in consumption of current between it and the 500-watt lamp, and also much less power of illumination. The Nernst lamp, therefore, appeared to us to meet the conditions above noted, and also to open a field for use of current which we could not otherwise obtain. It would be a strong competitor of the Welsbach light and of the Humphrey gas arc. Another consideration was that it would serve as an educator in the use of electric lighting, with but small expense to the customer.

In one instance we installed one Nernst lamp in a store that was using Welsbach burners; after the lamp had been in use a little over a month the customer wired his store for 11 inclosed-arc lamps and about 50 incandescent lamps, abandoning entirely the use of gas. In another case we displaced a Humphrey gas arc with a Nernst lamp to the complete satisfaction of the customer, both as to quality of light, and cost.

I give below some observations as to the renewals of glowers and general behavior of the few Nernst lamps that we have put out in regular service:

Lamp No. 1: Three-glower, installed February 1st; March, all glowers changed on account of burning dim. Current consumed February 1st to April 23d, 117.2 kw-hours; cost to customer, $7.55 net.

Lamp No. 2: Three-glower, installed January 29th. Current consumed January 29th to April 23d, 51.2 kw-hours; cost to customer, $4.77 net. This lamp burning well May 1st, with no change of glowers, and with apparently small decrease in illumination.

Lamp No. 3: Six-glower, installed January 6th at one of our sub-stations to burn all night, every night. This lamp was equipped with a small inclosing globe and shade. January 16th, one glower burned out, and globe badly blackened. January 23d, two glowers burned out. February 28th, put in new set of glowers. May 6th, one glower burned out. Current used January 6th to May 6th, 297.5 kw-hours, with four glower renewals, or one glower to each 74.3 kw-hours, or 1,486 50-watt lamp-hours.

Lamp No. 4: Six-glower, installed March 4th. April 8th, one glower burned out. Current used March 4th to May 6th, 155 kw-hours, or one glower for 77.5 kw-hours, or 1,550 50-watt lamp-hours.

Lamp No. 5: Three-glower, installed February 25th. No renewals. Taken out, and customer installed 11 inclosed-arc lamps.

Lamp No. 6: Three-glower, installed February 26th. March 19th, one glower burned out. Current used February 26th to April 23d, 27.1 kw-hours at cost to customer of $3.20 net. One glower for 540 50-watt lamp-hours.

Lamp No. 7: Three-glower, installed March 21st. May 7th, one glower burned out. Current used, 26.5 kw-hours, or one glower renewal for 530 50-watt lamp-hours.

We have not been advised as to the price the manufacturers intend charging for new glowers, but figuring on a basis in comparison with lamp renewals at half a cent per kw-hour, in the cases noted, would show cost for renewals as follows:

| | | | | | | |
|---|---|---|---|---|---|---|
| Lamp No. | 1 | 117.2 | kw-hours | $ .586 | 3 | glowers |
| " | 2 | 51.2 | " | .256 | 0 | " |
| " | 3 | 297.5 | " | 1.487 | 4 | " |
| " | 4 | 155. | " | .775 | 2 | " |
| " | 6 | 27.1 | " | .135 | 1 | " |
| " | 7 | 26.5 | " | .132 | 1 | " |
| | Total, | 674.5 | kw-hours | $3.371 | 11 | glowers |

Or an average of $.306 per glower.

No record has been kept of inspection, or time consumed thereon, it being more to our purpose to observe the working efficiency and adaptability of the lamp to commercial service than to obtain an elaborate record of costs.

The conditions observed by us are:

There is a tendency on the part of the glowers to warp, thus bringing them so far away from the heater as to make the lamp very slow in starting up, the shortest time noted being 30 seconds and the longest three minutes.

We have had only one complaint of light becoming dim, and this was only proven when the old glowers and holder were substituted for new ones. We do not think this dimming is attributable to the black deposit on the holder, but is due to some defect in the glower itself, as we have put new glowers in partly blackened holders without appreciable difference in the light.

Where we have found warped glowers we have been able to correct the lighting up by turning them partly over or bending up the terminals so as to bring the glowers closer to the heater.

We have as yet had no trouble from the giving out of the steadying resistance, or heaters.

To our mind, much the most important obstacle to be overcome is the prevention of the warping of the glowers, for on this depends the satisfactory operation of the lamp.

*First*—Because a glower that is warped will not light up quickly, and will consequently cause complaint from the customer.

*Second*—Tardy lighting up throws the heater into action for a longer period, and therefore necessitates its more frequent renewal.

If this condition is remedied and we find no further defects in their operation, which from our limited experience we can not look for, and the cost of glower renewals is not excessive, we feel that owing to the fact before noted—that there is a field for it—the lamp should come into quite general use.

E. F. Phillips,
Detroit, Mich.

The results thus far have been satisfactory to most of our customers and to ourselves. We have found it necessary to use care in supplying glowers of the proper voltage for the current furnished, as excessive voltage will soon destroy the glowers. With normal voltage some glowers will burn out within 100 hours, but if they burn for 100 hours long life seems to be assured.

We find that we can secure business with the Nernst lamp that we can not get with either the arc or incandescent, and that it competes successfully with the Welsbach.

The cost per kilowatt for supplying current for Nernst lamps is, of course, greater than for incandescents; on account of interest and depreciation in addition to cost of renewals and care of lamps, and we have therefore found it necessary to charge a higher rate per kilowatt if we furnish the lamps.

G. O. Nagle,
Savannah, Ga.

The results thus far from our use of Nernst lamps have been very satisfactory indeed.

F. H. Golding,
Branford, Conn.

*22.—Should the consumer or the station supply Nernst lamps, and how should renewals be taken care of?*

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We should prefer having the customer pay for and own the lamps, in which case we could furnish current at the same rate as for incandescent lamps; but we believe such a plan would result in less business than if the station furnished the lamps and made the necessary higher charge for current. The station should make all renewals free, and should also make regular inspections and exchanges of holders.

G. O. NAGLE,
Savannah, Ga.

We require the customer to supply the lamp, while we furnish renewals free of expense, as in the case of ordinary incandescent lamps.

F. H. GOLDING,
Branford, Conn.

We are now installing the Nernst lamps for commercial and residence use; the consumer will buy the lamps and furnish renewals.

J. M. UPTEGRAFF,
Sewickley, Pa.

*23.—Where are Nernst lamps being used for street lighting, and with what success?*

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We are using in Unionville, Conn., 125 single-glower and 15 six-glower Nernst lamps on the street-lighting service; these lamps covering all the street lighting that this company does. From the standpoint of the public they are giving excellent satisfaction; the light being a pleasant one, and the fact that double candle power is given for practically the same price being of much satisfaction to the public. From the standpoint of the company, we have not as yet sufficient data to judge of their commercial success, as we have been using these lamps only about five months. We can state, however, that we consider there is no question about the matter, provided a steady voltage is given the current; we finding that any very serious variations in voltage affect the life of the lamp.

THE UNION ELECTRIC LIGHT & POWER CO.

The Sewickley Electric Company, Sewickley, Pennsylvania, is furnishing Nernst lamps for street lighting. A six-glower lamp is used, and gives perfect satisfaction. The lamps have been in use since October, 1901. The glowers have given an average life of 1,300 hours. Lamps are inspected but twice a week—Wednesdays and Saturdays—and all burned-out glowers are renewed on these days. These street lamps are furnished and renewed by the lighting company.

J. M. UPTEGRAFF,
Sewickley, Pa.

*24.—Is the Nernst lamp in its present shape and at its present price a commercial success?*

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From investigation, and as a lighting company, we should say it is not. Our reason is that the Nernst lamp has been successfully developed to meet the conditions and standards for a very few central stations, and if adopted in its present form it would cost a great deal for change of system on the part of the electric-lighting company.

J. H. Perkins,
Youngstown, O.

*25.—What is the cp-hour life of a Nernst lamp to a depreciation of 20 per cent below its initial value?*

We have not yet run these lamps 800 cp-hours since we began to keep our records on this matter, but should judge that the average life would be nearly up to this. While they deteriorate somewhat, we do not believe that the deterioration is as noticeable as it is in an ordinary incandescent lamp.

The Union Electric Light & Power Co.,
Unionville, Conn.

## DISCUSSION

The President: Are there any questions to ask or answers to give in connection with the Nernst lamp questions? I think that Mr. Dunham or Mr. Rollins, of Hartford, has a communication on the subject.

Mr. Dunham: We have had these lamps in use for 15 months. The use we have made of the lamp has been principally experimental, to determine its value. Of course, not having any price for either lamp or glowers, it was not possible to determine the comparative economy of the lamp. But we have come to this conclusion—that the Nernst lamp is closely related to the arc lamp in the matter of trimming. Every arc lamp is a new lamp every time you trim it; every Nernst lamp is a new lamp every time you trim it; you have that advantage in a Nernst lamp as related to the arc lamp. It also requires about the same care in repairing and cleaning; principally in cleaning. It requires about the same care as an arc lamp, and, of course, we have a shop where we can take care of both the arc lamp and the Nernst lamp. The question that occurs to everybody is: How often can you afford to trim the lamp, and what will it cost; that is, as related to the arc lamp? As regards the relation of the Nernst lamp to the Edison incandescent lamp, you can, of course, put it on any socket where you can burn an Edison lamp. You have a better quality of light; I do not think anyone will question that. You have a soft, brilliant light; not too bright, but compared with the Edison lamp it is a superior light. Of course the power question is not so important, except in the saving of machinery. You make a great saving in your installation of machinery and in all the various line systems and underground work, by putting in half the current. I expect to install about 5,000 of the Nernst lamps this coming year, which shows that we have confidence in them. I have no doubt whatever (although it is a lamp of luxury, as was the Edison within our recollection; for we remember when we paid 75 cents for a lamp, and it did not last very long either, still it came down in price slowly) that the Nernst lamp will come within our reach as a bread-and-butter lamp more rapidly than did the Edison, because it has severer competition. It must be put in such shape that it can be manufactured on a large scale, but you can not reduce prices until you do manufacture on a large scale. I think the lamp is certain to be a success.

MR. WILLIAMS: As I understood Mr. Dunham's remarks, they were to the effect that he has found it necessary to bestow upon the Nernst lamp, to get entirely satisfactory results from its use, about as much attention as is required to get satisfactory results from the arc lamp.

THE PRESIDENT: Are there any further questions or comments on the Nernst lamp?

MR. FERGUSON: I ask Mr Wurts, who, I understand, is to close the discussion, kindly to tell us, when he replies, what developments have been made toward the direct-current Nernst lamp, or the Nernst lamp for use on direct currents. What are the prospects for a good lamp for use on that service?

MR. WILLIAMS: I would add a question, if not asked already, as to the measurements that have been made to show the energy consumption per candle power in the Nernst lamp; referring to the basis of measurement applied to the incandescent lamp.

MR. DUNHAM: I omitted to make the statement that you get a better distribution value than you get with the arc lamp. You get all the advantages of distribution in the Nernst lamp that you get in the Edison lamp, which you can not secure with the arc lamp.

MR. MCGEE: I ask if it is possible to burn the lamp in any other than the vertical position.

MR. DAVIS: What is the supposed rate of deterioration or depreciation? Is the useful life supposed to be 800 hours, less than 800 hours, or more than 800 hours?

MR. HALLBERG: What are the maximum and minimum voltages for the Nernst lamp?

Mr. Mordock: We have not gone into the Nernst lamp commercially, but have been burning a 60-cycle, 208-volt lamp for about 1,100 hours, and we find that as the candle power falls off, the current also falls off. At the start, it consumed about 170 watts, and after burning about 1,100 hours, consumed only 140 watts.

The President: We will ask Mr. Wurts to close the discussion.

Mr. Wurts: I want to call your attention first to the life of the glower, as referred to in the Sewickley letter, which claims 1,300 hours. You should understand that their frequency is 125 cycles. In regard to the remark made in the answer from Savannah—that if the glower ran 100 hours it then had a long life—I want to tell you that one of the chief causes of the early breakage in the glower thus far has been the mechanical strain on the glower. Unfortunately, those who use the lamps have not the information we should like them to have, and they are not aware of the fact that the glower expands and contracts, particularly at times of lighting and turning off. The glower should be perfectly free, and should have an end play of about one-sixteenth of an inch. If it has this end play, no mechanical strain will be brought upon the glower, and the average life, barring a defective glower or accident, should be 800 hours on 60 cycles. Right in line with this remark, I will answer the question with reference to frequency. The life of the glower is 800 hours on 60 cycles, and 400 hours, apparently, on 25 cycles; we have not full information on the latter point; experiments are being carried on in Buffalo, on the circuit from Niagara Falls, that indicate a considerably longer life than 400 hours, but these experiments have not been completed, and I can not say anything definite at this time. The figure of 400 hours that I am giving you is based on results obtained from about 350 six-glower lamps that are operated in the factory of the Westinghouse company on 25 cycles. On the 16,000 alternations, the life seems to be about 1,200 hours. The experiments on that number of cycles have not been exhaustive, but the indications are that the life is about 1,200 hours.

As to the cost of trimming, we have not very complete data; I think we must look to the central-station men for that information. The Westinghouse Machine Company has a large number of six-glower lamps in its factory, and has kept a record of the labor required to take care of the lamps, and the figures indicate that it requires a one-man hour for 800 lamps on the six-glower lamp. I have not verified these figures, and do not know anything about them personally. This statement is taken from that company's records.

As to the prospects for a direct-current lamp. You probably know that our European friends have labored along the lines of a direct-current lamp, exclusively. They have not, so far as I am aware, made the alternating-current lamp, so the direct-current lamp is not only a possibility, but a fact. We think we are doing wisely to work along the lines of an alternating-current lamp, rather than to parallel their work. As a result, we have found that the life of the glower on the alternating-current is much greater than on the direct current, and we have continued along the line of alternating-current work with the idea of putting our best foot forward first. But we are now making direct-current glowers, and we propose to put them on the market very shortly. We shall probably be in position by the first of September to supply direct-current lamps in quantity. One other interesting feature in connection with this subject is that all lamps will be exactly the same, whether for direct current or for alternating current; that is, by the lamps, I mean everything in the lamp except the glower; the direct-current glower will be different from the alternating-current glower. The same remark applies to lamps for different voltages. As an illustration, take the 220-volt, six-glower lamp; if adjusted for 200, 230, 240 volts—or whatever it may be—the lamp will be the same in every respect except the glower.

As to the position that the lamp must occupy, we have only made lamps thus far that will operate in a downward, vertical position. The reason for this is that the cut-out operates by gravity. For any special cases we could reverse the position of the cut-out in the lamp, and in that case the lamp would operate in an upward, vertical position; but we have felt that the light should be thrown downward instead of upward, and have taken no steps to make a lamp that will operate in any other position than the downward. We have endeavored to make what we call a "universal lamp;" that is, a lamp that will operate in any position; but that would require something in the nature of a spring for a cut-out, and we have found that a spring is not always reliable.

What is the useful life of the glower? Possibly that is a good deal a matter of opinion. The total life of the glower seems to be, as I have stated, about 800 hours on 60 cycles. Whether or not that would be considered the useful life, must be determined by you. Nevertheless, even at the end of 800 hours the glower still has an efficiency that will compete with other lamps now in use.

As to the range of voltage. I think there is a a very great misunderstanding on this point. I find that most people think that the Nernst lamp is very sensitive to changes in voltage. I do not think that is the case at all. I think that idea has arisen largely from the fact that in every case we demand the accurate voltage of the circuit upon which the lamp is to be operated, and our object in requiring a statement of this voltage has been that we might be able to place the lamp before the customer under the best possible conditions. In a great many cases where an incandescent lamp is bought and placed on the circuit, and not much attention given to the question of voltage, and the life of the lamp is short, you think nothing of it and simply replace the lamp; but the Nernst lamp being new, the customer watches it critically to see if it lives up to the claims made for it by the manufacturer. As a result, we think it wise to request reasonably accurate figures with regard to voltage, so that we can adjust the lamp at the factory for that particular voltage. I have found in a large correspendence, extending over six months, that very few of the central-station people realize what a very great change there is in candle power for a very small change in the line voltage. There is a drop, I believe, of 40 per cent in candle power in an incandescent lamp for a drop of five per cent in voltage. This being the case, it is very important to have the correct voltage if the new lamp is to make a good impression. The variation of candle power in the Nernst lamp for a rise in voltage, however, is exceedingly small compared with the variation of the incandescent lamp. The variation in candle power for a five-per-cent rise in voltage is only 12 per cent in the Nernst lamp. The effect of an increased voltage on the Nernst lamp has been about as follows: five-per-cent rise does not seem to affect the life of the glower materially; that is, a five-per-cent rise for periods of hours at a time. Probably a five-per-cent increase in voltage running continuously would make a little difference in the life of the glower. A 10-per-cent rise running continuously will blacken the ballast tube. A 15-per-cent rise will make the ballast tube very black, and a 20-per-cent rise will heat the ballast tube sufficiently to soften the glass bottle containing the ballast. On inspection of the lamp, therefore, we are able to determine pretty closely how the lamp has been treated. But in the light of my experience with the Nernst lamp, I feel it is impossible to burn out the glower inside of 200 hours, on account of the very high corrective power in the ballast. It is impossible with a rise, say, of 10 or 15 per cent in voltage to increase the current in the glower sufficiently to burn it out. The ballast will go first if the voltage is raised about 15 per cent and run continuously at that increase. So I feel very confident that, if a glower gives out in less than 200 hours, the breakage is due to mechanical strain.

MR. WILLIAMS: There was one question asked that was not answered by Mr. Wurts, which is as to figures on the efficiency of the lamp.

MR. WURTS: The efficiency question is a difficult one to answer satisfactorily. It seems to me—and I think most of you will agree with me—that the efficiency of the lamp should be based on its earning capacity. But many of you will wish to know the efficiency of the lamp as given by the photometer bar. We have, of course, made many measurements on the photometer, and these measurements have been of value to us in guiding us in our work; but we have not yet found any customer that cared anything about the measurements thus made. The dry-goods man, the hotel, or the office-building man, cares nothing about these measurements. If he can see the light, and see the general distribution and quality of the light, and how it compares with other lamps with which he is familiar, he makes up his mind whether he wants the lamp or not. We have given the lamps a nominal rating. The one-glower is called a 50-cp lamp. This is a purely nominal rating, and we have obtained it by measuring the candle power on the photometer bar in the direction of greatest intensity; thus the one-glower lamp gives 50 candle power in the direction of greatest intensity with a clear-glass globe. But we have devised for ourselves our own kind of photometer, and it is hardly new either. In our exhibition room we have placed a ceiling cluster of four one-glower lamps, with sand-blasted glass globes, and in four corners of the ceiling we have placed four clusters of three incandescent lamps each, having clear-glass globes and reflectors, making 12 16-cp incandescent lamps altogether; and it is the opinion of everyone who has been in the room that there is a great deal more light—better illumination—from the four one-glower Nernst lamps than from the 12 16-cp incandescent lamps. Most people say offhand that we are getting twice as much light from the Nernst lamps. I think a very conservative figure would indicate that the Nernst lamps are giving one-third more light. We have, then, four single-glower lamps, taking 352 watts. The candle power is measured by the 12 16-cp units in the ceiling (and, by the way, all the incandescent lamps have reflectors over them, while the Nernst lamps have none), and from these we get our candle power. That is to say, the 16-cp incandescent lamps are taken as the standard, and with these data and the power supplied to the Nernst lamp, we obtain the efficiency of the Nernst lamp; and we estimate that it approximates one and one-half watts per candle. We thus have a fair and conservative figure for the efficiency of the Nernst lamp. The efficiency could be made a little higher or a little lower, according to the manner in which you care to consider it. Take the six-glower lamp, for instance; that is a large unit, and in most cases it is desirable to throw the light down, and we find the mean spherical candle power of the six-glower lamp, from a 30-degree zone, to be one watt per candle; from a 60-degree zone, about 1.23 watts per candle.

### *26.—Is it desirable to ground secondaries, as permitted by Rule 13a of National Underwriters' Code?*

I believe that secondaries should be grounded, but do not know the best way to do it.

F. Ellwood Smith,
Somerville, Mass.

We believe that it is impossible, *i. e.*, impracticable, to maintain grounds sufficiently good to protect from accidents, and even if that difficulty were overcome it would still be a question if the same expense would not be better applied to proper precautions to prevent such accidents as occur, by so arranging that grounds could not be made by users of ordinary care. It must be an unusual strain upon the transformer insulation, especially in lightning storms; but if it must be done, then let the customer do it and maintain the ground, or we shall have gained nothing by such a course. The experience we had with grounded-transformer cores should not be forgotten. The practice is entirely abandoned, and for similar reasons perhaps grounded secondaries would also be objectionable if the practice became extensive.

R. J. PATTERSON,
Waterville, Me.

I think it very important to ground the secondaries of transformers, as in the case of a cross between the primary and the secondary lines it would be a protection to the houses, also in case of a breakdown between the primary and secondary winding.

F. L. SARGENT,
Malden, Mass.

I am inclined to favor the grounding of secondaries, but am awaiting results from such practice before coming to a conclusion. Two secondaries grounded about three weeks ago have given me no trouble. Several storms have prevailed since, in which a number of old transformers, accidentally grounded on one leg of secondaries, have burned out.

W. J. GREENE,
Cedar Rapids, Ia.

I have not availed myself of the right to ground secondaries, as permitted in Rule 13a of National Underwriters' Code, because I feared it would lead to carelessness on the part of employees and contractors. Should a house become grounded, instead of removing the ground it would be a very natural thing simply to throw the grounded side on to the grounded side of the secondary system. Outside of this fact, I believe grounding is a wise precaution and should be adopted. ANONYMOUS.

We are in favor of grounding the neutral on one line of the secondary system, as we believe it offers better protection to life and property, for the following reasons:

With one leg properly grounded, the maximum potential between any secondary wire and ground would be practically limited to the lamp voltage, as in case of a breakdown between primary and secondary there would be a path to ground through the grounded secondary terminal. With an inter-connected secondary system, the electrostatic capacity might be troublesome, and even dangerous, which condition is entirely eliminated by grounding one terminal.

The method of grounding depends entirely upon the nature of the soil and sub-soil of the locality where it is desired to establish a ground. Methods that are very satisfactory in some localities will not do in others. In Chicago, it is a comparatively easy matter to establish a good ground by burying a copper plate at the time the pole is set, or by driving a one-inch gas pipe to a depth of, say, six to eight feet.

P. JUNKERSFELD,
Chicago, Ill.

***27.**—Is the method of insulation service wires recommended by National Underwriters' Code desirable?*

Rubber-covered wire is unfit for insulating purposes if exposed to the weather, and where rubber-covered wire is used it should be covered with weatherproofing.

ANONYMOUS.

***28.—Should the neutral or one of the outside wires of a secondary system be grounded?***

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If one of the three wires of a secondary system is to be grounded, the neutral is the one, for in this case it is only possible to get 110 volts on a 110-220-volt system in case an accidental ground is made on either of the outside wires. H. H. SCOTT,
Lincoln, Neb.

I should think it would be much better to ground the neutral. F. L. SARGENT,
Malden, Mass.

We should advise grounding the neutral wire if any. As the difference of potential between the neutral wire and either side is but half of the potential between the two side wires, and would therefore make less trouble, should either of the sides become grounded, than might occur if one side was grounded and the opposite side should accidentally be grounded.
JAMES E. PYLE,
West Chester, Pa.

The neutral wire should be grounded.
P. JUNKERSFELD,
Chicago, Ill.

***29.—What degree of accuracy in regulation should be required in each part of the distributing system between the station switchboard and the consumers' meters?***

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In an alternating-current plant, it is possible and practicable to maintain regulation within two per cent, and I therefore think this should be the maximum limit allowed. In a direct-current plant, it is possible, but not practicable, to maintain regulation within these narrow limits, and the question then resolves itself into one for purely commercial consideration. Two-per-cent regulation in direct-current plants is a myth, in spite of the statements of the managers and engineers of direct-current stations. The last two-per-cent station I struck had a real regulation that was equivalent to about four times this in actual results. When I speak of two-per-cent regulation, I mean that the pressure at any point in the city shall not vary more than two per cent from maximum voltage.

ANONYMOUS.

*30.—What method of protection should be used when transformers are operated with interconnected secondaries to prevent a short-circuit at one point from blowing the fuses on all the transformers feeding the connected network?*

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Use fuse junction boxes on secondaries, electrically midway between transformers, the size of the fuse depending on how much you wish to overload any one transformer.

H. H. SCOTT,
Lincoln, Neb.

Divide the secondaries into sections by fuses of small ampere capacity placed at points where they will carry small currents, except in cases of short circuits.

W. T. OVIATT,
Bridgeport, Conn.

We use the same plan of interconnecting transformer secondaries that we do on the mains of our three-wire Edison system, and have never had any difficulty from short circuits blowing except in the section wherein the trouble existed.

C. R. Maunsell,
Topeka, Kan.

If secondaries from several transformers are interconnected, we must insert fuses at the middle point electrically between transformers, to prevent trouble at one point from extending over the entire network. The carrying capacity of these fuses depends on the size of the transformers, the cross section of the secondaries, and the distance between transformers. They must be large enough to allow one transformer to help out its neighbor in case of overload at one point, but they must also be light enough so that a short circuit at any point on the network will blow the junction fuses before the primary fuses on next adjacent transformers give way. This isolates the defective transformer and its secondary system, and does not throw out the entire network.

We may not be able to select a size of junction fuse that will blow at exactly the proper time for all conditions of load, but we may approximate it by slight changes in the primary fuses to accommodate certain conditions. Suppose we desired that a transformer be able to send half its output to the next district, then the junction fuses should have half the current capacity of the transformers, and in case of a short circuit with full load equally distributed, the primary of the transformer affected would blow and each transformer would send current to the defective district. If the cross section of the secondaries is ample and the distance not excessive, the resistance of the short circuit is very low compared with the normal secondary circuit through the lamps, and the greater portion of the current tends to flow through the junction fuse, thereby blowing it before the primary fuse goes. This is the result that would naturally be expected, but experience shows that this does not always occur with transformers fused to their rated capacity; probably for the reason that the primary fuse is already warm from carrying normal load and the junction fuse is cold at the time the trouble occurs. If we expect the junction fuses to carry half the normal load of the transformers, the primaries of the transformers must be fused slightly above rated capacity, in order that trouble may not extend beyond one. district. If we can distribute transformers so that it is not necessary for them to send more than one fourth or one-third of their rated load to the adjacent districts, it is usually safe to fuse primaries to their rated capacity. For an interchange of load for more than one-third of the rated capacity of the transformers, I think that primaries should be fused slightly above the normal capacity of the transformers, in order that junction fuses may do their work properly. This is not likely to cause any damage to the transformers, as short circuits will blow very heavy primary fuses before any damage is done to the transformer.

L. G. VAN NESS,
St. Paul, Minn.

The protection of interconnected secondary systems is a problem that can be satisfactorily solved only in particular cases, as there are too many local conditions

entering in to make it possible to lay down general rules. In cases where the load is comparatively dense, a carefully designed system of fuses, so placed that a section of the secondaries will be cut out in case of serious trouble, is probably the best method of protection. In residence districts, or similar territory, where the load is not so dense, it has been found preferable in Chicago to allow each transformer to feed its own secondary without interconnection on the secondary side. H. B. GEAR,
Chicago, Ill.

We have several interconnected secondaries upon which are operated different numbers of transformers. We have no protection between the secondary coils of the transformers and the secondary mains, our only protection being the junction fuse on the primary side, fused for 150 per cent of transformer capacity. From our experience, trouble arises so seldom as not to necessitate other protection. E. J. BECHTEL,
Toledo, O.

### DISCUSSION

THE PRESIDENT: Does any gentleman present wish to express his views on this question?

MR. LEONARD ANDREWS (Hastings, England): This is a question in which I have taken considerable interest. In our system, in Hastings, we have our low-tension network connected together and it is fed by transformer sub-stations at various points in the town. We have found that it is useless to attempt to put fuses in any position in the low-tension network, as a failing transformer invariably short-circuits the network without blowing the fuse between that and the network, and blows a number of fuses in other places, often cutting off the supply to the whole district.

We use return-current cut-outs between the secondaries of our transformers and the low-tension network, that is to say, cut-outs that only operate when a transformer ceases to supply energy from the network. We have all of our transformers equipped in this manner, and we have not the slightest hesitation in short-circuiting either the primary or secondary winding of the transformer connected to the network at any time, as the automatic return-current cut-out referred to can invariably be relied upon to cut out the faulty apparatus.

*31.—Is it not just as necessary to protect long services and interconnected secondaries from lightning as it is necessary to protect our primaries?*

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I should say, yes. F. L. SARGENT,
Malden, Mass.

I believe that it is necessary to give better protection to long services and interconnected secondaries than to primaries of equal length, otherwise the consumer's premises, with the usual low insulation from earth, would become a dangerous lightning arrester.

W. J. GREENE,
Cedar Rapids, Ia.

If it is desirable to ground the secondaries, no lightning arresters will be found necessary, particularly if the transformers work on the three-wire system with the neutral grounded. In this case we have found that no static discharge sufficient to do any damage can accumulate. C. R. MAUNSELL,

Topeka, Kan.

An affirmative answer to this question is almost self-evident if the following considerations are remembered:

The location and length of the line being fixed, the chance of serious increase of pressure due to the lightning discharges is equally great regardless of the working pressure to which the line is subjected in normal service. Secondary lines have in the past usually been of comparatively limited length or their location has been protected, and for this reason lightning protection of secondary lines has not always been found essential. The primary lines, on the other hand, have been more extended and in more exposed positions, and experience has shown that lightning protection with them is essential. This need is particularly caused, however, by the length and exposure of the lines and is not indissolubly linked with the higher working pressure which they carry. Cribbed or interconnected secondaries of great length have lately come into general use with better alternating-current plants, and such secondaries, when overhead, require protection from lightning which is the full equivalent of the protection of primary lines.

The necessity for the protection of the secondaries is sometimes not felt so acutely as is the necessity for the protection of the primaries, because a serious arc due to the dynamo pressure will not always follow every slight injury to the insulation of the secondary wiring that may be caused by lightning. Such an injury, however, will almost always cause trouble ultimately, and will, perhaps, result in ultimate serious damage. The possibility can be avoided only by properly protecting extended secondary and service wiring from the effects of lightning.

Dugald C. Jackson,
Madison, Wis.

We have no lightning arresters on our interconnected secondaries (our longest being between three and four miles of three-wire mains), and have had no trouble chargeable to this cause since the system was started in 1897. We have not, however, decided that this is the proper method, and should like to hear from others?

E. J. Bechtel,
Toledo, O.

The President: I do not think it is customary, as a rule, to protect the secondaries from lightning. Personally, I agree with Professor Jackson, that it is more essential to protect the secondaries than the primaries.

*32.—What form of lightning arrester best lends itself to use upon secondaries?*

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This question is more difficult to answer than its predecessor; but assuming the secondary to be carrying alternating currents, which is the apparent intention of the question, I think it is safe to say that the lightning arresters should be one of the following types:

1. Cylinder non-arcing type, with very narrow air gap and non-inductive resistance in series therewith.

2. A type with electromagnetic arc interrupter and non-inductive shunt for a path for the lightning around the electromagnetic coil.

3. Perhaps a type depending upon a high resistance leak, like the Wurts charred-wood arrester.

Either of those types *properly* made to protect low-pressure lines ought to serve the purpose admirably, and their construction admits of their being placed upon the pole line in proper boxes. The manufacturers ought to pay more attention to the requirements to be met in this service.

DUGALD C. JACKSON,
Madison, Wis.

### DISCUSSION

CAPTAIN BROPHY: One serious difficulty in making lightning arresters efficient when the transformer is placed on poles or outside of buildings, as they usually are, is the matter of securing a good ground connection at all times. A ground wire running a long distance on a building, or if it is run down a pole, is apt to be broken, rendering your lightning arrester useless. So long as transformers are thus placed, I think the lightning arrester will be rather inefficient and unreliable. Again, it would be very difficult to get a good ground at the bottom of the pole. The only reliable ground—which is not really a ground—is a connection with the water system of a city. There you get what we call a reliable ground, but it is not a ground at all. Most of the ground wires are connected to plates buried or bars driven into the ground at the bottom of the poles, and they are worthless in dry, sandy soil, or where the soil rests on a rock bottom.

MR. GILLETTE: Would it not be good practice, in running a ground wire for lightning arrester through an iron pipe that is to act as a protector for the wire above the surface of the ground, to make a connection at the top, where the wire enters, in order to avoid the choking effect a long piece of iron pipe might have on a lightning discharge?

CAPTAIN BROPHY: It would be far better to use the iron pipe as the conductor, carrying the pipe to the transformer and connecting the ground wire to the pipe. It is not necessary to use wire inside the pipe.

THE PRESIDENT: If you were going to use copper wire, you would advise grounding the wire at the top of the pipe?

CAPTAIN BROPHY: Yes, sir.

*33.—Which is preferred on alternating-current systems to indicate regulation: A system of pressure wires or a compensating voltmeter?*

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A compensating voltmeter for long distances and pressure wires for short distances.

W. T. OVIATT,
Bridgeport, Conn.

In our Edison three-wire plants we have had excellent results from the use of pressure wires, which are run to the office of the company, situated practically at the centre of distribution, and there connected at will, by means of a voltmeter switch, to any one of the various feeder ends. As it is customary to regulate the central-station voltage according to some standard feeder, only one main set of pressure wires is really required, and the plan above outlined enables one to test the voltage at feeder ends when required for comparison. It also avoids the necessity for occupying valuable space on the main pole lines with a multitude of small pressure wires. We maintain at the central office a pair of Bristol recording voltmeters connected to any desired set of pressure wires. The manager examines the charts every morning and sends them to the chief engineer or station superintendent, who makes such notes as he may require for the guidance of the switchboard attendants. This plan works admirably in practice, our regulation being good and lamp breakage low in proportion to the number of lamps connected. H. T. HARTMAN,

Philadelphia, Pa.

I much prefer compensating voltmeters over pressure wires on our system, as our system is entirely over head and using pressure wires necessarily makes us much more overhead construction to maintain, and causes trouble during storms. We have very good regulation, using practically the same method as compensating voltmeters. F. L. SARGENT,

Malden, Mass.

We used to have pressure wires on every feeder. Last fall we installed compensating voltmeters, doing away with the pressure wires, and they answer every purpose. I much prefer compensating voltmeters.

F. ELLWOOD SMITH,

Somerville, Mass.

We unhesitatingly favor pressure wires in place of compensating voltmeters, although we are aware that the makers claim they will compensate for any ordinary drop on lines. We have these in use upon four of our circuits, but find them anything but satisfactory; in fact, a man by means of hand regulation can come nearer making up for line drop by guessing than he can by keeping a voltmeter on the dot and relying upon the action of compensator.

CHAS. H. PETERS,
Durango, Col.

I should think that it would depend upon local conditions. If three-wire secondaries were used the three pressure wires would surely give satisfactory results, provided it did not cost too much to erect and maintain the pressure wires. If the pressure wires were tied into the secondaries some distance from the transformer they would indicate the load balance on the secondary of the transformer in many cases. Compensating voltmeters, with due care in balancing the load on three-wire secondaries, in case three-wire secondaries were used, should be much less cumbersome and in most cases preferable.

JAMES E. PYLE,
West Chester, Pa.

In alternating-current distribution systems, compensating voltmeters arranged for inductive and non-inductive drop are preferable to a system of pressure wires. The first cost, as well as maintenance, will be less; and if compensating voltmeters are properly adjusted better results will be obtained.

P. JUNKERSFELD,
Chicago, Ill.

In alternating-current distribution, compensating voltmeters have an advantage over pressure wires returning from long distances, in that they are simpler, not apt to be out of order when wanted, cost less for maintenance, and are just as reliable when adjusted and used in connection with systematic tests and inspections at the consumer's connection. This inspection is advisable under any system.

E. J. Bechtel,
Toledo, O.

Pressure wires are better than compensator, in that they give account both of drop on primary line and also of drop in transformer whether the power factor is high or low. A compensator could be adjusted to allow for transformer drop, provided the power factor were the same from day to day. On the other hand, the pressure wires are liable to give false returns, on account of induction from other circuits. With careful adjustment, I should expect the compensator to be less troublesome.

George D. Shepardson,
University of Minnesota.

*34.—Is it practical to use three pressure wires on a three-wire secondary system?*

So far as we can see, there would be no objection to using three pressure wires upon a three-wire system, although the neutral pressure wire seems unnecessary.

Chas. H. Peters,
Durango, Col.

If the primary feeders are short. If the primary feeders were very long the maintenance of the pressure wires would be expensive.

James E. Pyle,
West Chester, Pa.

I should say, yes. GEORGE D. SHEPARDSON,
University of Minnesota.

*35.—Is it practical to use three pressure wires on a three-wire secondary system, one wire being a common neutral for all pressure wires?*

In answer to this question, I should say that a system of pressure wires having a common neutral would not indicate the pressure at the different parts of the system so well as separate neutrals would. In case of a bad balance on any part of the lighting system, the difference of potential between the two outside wires could remain standard, while the heavily loaded side would be low and the lightly loaded side would be too high. JAMES E. PYLE,
West Chester, Pa.

I should expect unreliable readings if one circuit were badly out of balance.
GEORGE D. SHEPARDSON,
University of Minnesota.

*36.—Are twin conductors desirable for service wires?*

We find twin cable expensive, but invaluable for services on front of buildings, and appreciated by customers. EDWARD SLADE,
Quebec, P. Q.

I am of the opinion, gained from the use of them, that they are not. I have put in for house-service wires an iron pipe or tube running from the pole in the street in through the cellar wall. Into this pipe I have drawn twin, rubber-covered, solid conductors with heavy outside braid. Faults have occurred, and one of the conductors has become grounded in the pipe, necessitating the withdrawal of the twin, and it is not a good job to cut the twin apart, insulate the break, and draw the twin in again with the bunch on it where the repair is made. I have used some twin lead-covered cable, built for 3,000 volts and used on 2,200. This twin was used in an iron tube in the usual manner, but broke down inside of one year's service, with the consequent loss of this section of twin conductor. To my mind, it is far better to use single conductor, and a faulty one may easily be withdrawn and a new one substituted. The faulty one may then be repaired much better, and the more readily, as a single conductor than as a part of twin conductor. WELLES E. HOLMES,

Newton, Mass.

## DISCUSSION

THE PRESIDENT: I think that question was asked regarding low-pressure secondary service wires, and I take it that Mr. Holmes is speaking altogether of primary service wires.

MR. HOLMES: In the first case I spoke of the 104-volt distribution, but in the second case I referred to the lead cable of the primary distribution, and covering both forms.

CAPTAIN BROPHY: Secondary twin wires should be carried inside. The great advantage would be in having the insulation between the wires much lower than the insulation between the pipe and the insulation covering outside of the two wires. Ninety-nine per cent of the fires due to electricity are due to series arc, or arcing between the wires or arcing at the connections. I have taken wires covered with the most inflammable material—cotton braid filled with paraffin—and brought them up to the melting point without being able to get a blaze from that material while with an arc established at one end it will surely take fire. We are not afraid of short circuits, so far as fires are concerned, because your fuses will take care of that by opening the circuit. If you can bring your wires nearly together your fuses will act. There is a great advantage in using the twin wire if you can make it right; but the insulation between the two wires should be much less than the insulation between the pipe of the wire, for that reason.

***37.***—*What are the relative advantages of induction-type meters and commutator-type meters?*

The induction has the same advantage over the commutator meter that the induction motor has over the commutator motor, in that there are no brushes to spark, wear the commutator, or get out of place. This is a decided advantage where there is any dirt getting inside the case. The induction meters are easier to clean and to repair and the repair parts are cheaper, as with this meter there is no armature or expensive commutator and brushes.

J. E. Barker,
El Paso, Tex.

Induction meters are better, for there are few chances of the meter going dead, and they can be

made just as accurate; also from the fact that the moving parts are lighter. E. H. JENKINS,
San Antonio, Tex.

The commutator-type meter, when properly compensated, registers with commercial accuracy equally well on both direct and alternating-current circuits of the usual frequency, and also on inductive and non-inductive loads. This interchangeability is often of great service where station has both direct and alternating current.

The chief disadvantages of this meter are due to commutator and brush troubles, and also to the trouble with jewels incident to the relatively heavy rotating parts. Recent improvements, however, have tended greatly to reduce these disadvantages.

The chief disadvantages of the induction-type meter are that it is applicable to alternating currents only, and must be adjusted to any large difference in frequency.

Its general advantages over the commutator meter are as follows:

1. Absence of commutator and brush trouble.
2. Reduced jewel troubles, due to lightness of moving parts.
3. Saving in shunt losses; the losses being one-third or less that of commutator meters.
4. Can usually be tested more easily and quickly.
5. Requires less repairs, and the cost of repair parts is less.
6. Is more sensitive on light loads.
7. Remains in calibration longer.

We use the commutator-type meter on all direct-current circuits, and are now installing the induction-type meter on all alternating-current circuits. We have recently replaced all commutator type of switchboard meters with the induction type.

George Ross Green,
Philadelphia, Pa.

The conditions under which a meter is used are so variable that neither the commutating type nor the induction type can be considered a superior meter for all conditions of service. The one principal objection that can be urged against the commutating meter lies in the commutator itself.

It must be recognized that when first installed, with the commutator clean and the meter so adjusted that it does not creep, the accuracy on light loads will continually diminish for the first two months. At the end of that period, if the meter is visited and corrected (not by cleaning the commutator, which should be left in its tarnished and constant condition, but by moving in the adjustable shunt), it is not expected that further deterioration will occur. This has been the experience of at least two of the large users of commutating meters.

In those stations where the meters can receive but little attention, and where this inspection and adjustment can not be made, it is probable that greater revenue will result from the use of induction meters. The objections to the use of induction meters, on the other hand, are considerably more numerous:

(1) The theoretical law of the meter is such that the curve will not approximate a straight-line law as closely as will a meter of the commutating type, although from light loads to considerable overloads this curve can be held reasonably straight by a proper

proportioning of parts, and is so held in several of the prominent makes of induction meters.

(2) Induction meters are particularly susceptible to changes in wave form, which is not true of the commutating type.

(3) In those plants where both alternating current and direct current are used, or where currents of two frequencies are used, the interchangeability of the commutating meter from one circuit to another is a matter of considerable importance. Induction meters can not be so interchanged.

(4) There is unquestionably an aging of an induction meter, which ultimately affects its light-load accuracy and may be compared to the aging of the commutator. This is due to aging in the iron used in the construction of the meter, and it is impossible to say to what extent trouble due to creeping may be introduced.

(5) The induction meter must be looked upon as a device not thoroughly established, and subject to considerable change from year to year. I do not believe there is a single company in this country that has not materially changed its design of induction meter at least once or twice. On the other hand, the early commutating meters, which have been used for twice the period of the oldest induction meter, can be made comparable with the modern meter by the addition of an adjustable shunt; an indication that the condition of manufacture has become reasonably constant.

(6) And most important. Induction meters as a class may be designated as "low-torque meters," and as such are liable to greater changes in accuracy, due to an equal change in the friction of the running parts. If the total torque on a meter shaft is directly

proportional to speed, it can be shown that the meter is mathematically accurate for all conditions of load. The principal torque of a meter is proportional to the energy in the circuit, and the principal drag (*i. e.*, the Foucault current drag) is proportional to the speed.

All meters have some friction which must be compensated for, and this friction is the disturbing element that introduces inaccuracies after long periods of use. It is not so necessary to have friction extremely small as it is to have friction variation small. I am very much inclined to the belief that a discussion of the relative merits of induction and commutating meters will of necessity centre on a discussion of torque.

FRANK COX,
Schenectady, N. Y.

Advantages of induction-type meters for alternating current are:

*First*—They are more accurate on light load.

*Second*—Accurate on inductive loads.

*Third*—Have lighter moving parts and consequently less wear on jewels.

*Fourth*—Have no increasing friction due to brush contacts.

Commutator meters have the advantage of strong torque.

O. J. BUSHNELL,
Chicago, Ill.

The advantages of commutator-type meters are:

*First*—Independent of frequency.

*Second*—Greater torque.

*Third*—They can be used on either direct or alternating-current circuits.

Advantages of induction-type meters are:

*First*—As many makes are at present constructed, they are dust-proof.

*Second*—Greater accuracy on light loads, both when new, and after use.

*Third*—No commutator to cause friction and inaccuracy, especially after deterioration by use.

*Fourth*—Will not creep.

*Fifth*—In one type now manufactured there is no jewel bearing to cause inaccuracy and change in the accuracy curve by deterioration.

*Sixth*—As a result of the above: Less cost of maintenance, greater revenue to the company, and less doubt on the part of the consumer. On the whole, we think that after one year's use the induction meter will show far better results than the commutator meter on every point except those noted, and these are of small importance when compared with the induction meter as manufactured to-day.

J. H. PERKINS,
Youngstown, O.

From a single-phase, alternating-current light and 500-volt, direct-current power central-station experience in the handling of both induction and commutator meters, the following five comparative values of both types of meters are drawn:

*Handling*—In the handling of meters we find favor given the induction type, its portable character enabling more rapid handling through meter department to point of installation, and *vice versa.*

*Installing*—The installing of meters gives favor to the induction type, owing to less care and judgment required in their placing and connecting up.

*Accuracy of Registering*—The percentage of fast and slow meters is higher per year in the commutator type.

*Repairs*—In the item of yearly cost of repairs to meters, the semi-yearly inspection and cleaning of the commutator of the meter bring this cost higher than that of the induction type.

*Constant Power Losses*—The constant power loss in the commutator type is higher than that of the induction type. ANONYMOUS.

### *38.—What general rules should be laid down for locating a meter on the consumer's premises?*

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A clean, dry place, not exposed to vibration or sudden jars, not more than eight feet or less than four feet from the floor; protected by fuses; service switch to be between meter and lights so that meter resistance coil will have current at all times current is on the line.

W. T. OVIATT,
Bridgeport, Conn.

A meter should, if possible, be located on the lower floor of a building, and in a position accessible at all reasonable times for reading and testing. Avoid, if possible, small closets, bath rooms, kitchens, and damp, dusty places. The meter should never be installed on door jams, wooden partitions having doors, or on any supports liable to unusual vibration. The meter should be placed about six feet above the floor, and sufficient room left above and below it for removing the cover and jewel. Too much attention can not be exercised in deciding on the proper location of the meter, as very frequently the loss of time when testing or reading, due to improper location, becomes a serious matter.

GEORGE ROSS GREEN,
Philadelphia, Pa.

Meters should be located in a clean, dry place, not subject to extremes of temperature, and free from vibrations. They should be easily accessible, not over six feet from the floor. When placed at service, the meter should be on house side of service switch, so that the current can easily be cut off from it.

O. J. BUSHNELL,
Chicago, Ill.

*39.—What are the relative advantages of index meter dials and direct-reading dials?*

One of the greatest advantages is that the latter lessens the clerical work.
F. L. SARGENT,
Malden, Mass.

In direct-reading dial there is less liability to mistakes in reading. The consumer can read his own meter, and thus a great many disputes as to bills may be avoided.
W. T. OVIATT,
Bridgeport, Conn.

The chief disadvantage of the direct-reading counter thus far placed on the market, is due to the liability of the cylinders to stick and thus prevent the meter from registering. But for this trouble, the direct-reading counter is. preferable to the index dial. As, however, the index dial is less liable to stick, it is generally preferred.
GEORGE ROSS GREEN,
Philadelphia, Pa.

Direct-reading dials have caused more trouble than index-meter dials. They are unsatisfactory, and have been given a thorough trial by both gas and water companies and have been abandoned. A good meter reader should not make more than one mistake to every thousand meters read when reading index-meter dials. If your errors exceed this figure, your men are careless and need disciplining. ANONYMOUS.

The direct-reading dial is very hard to read if several of the figures are partly turned, and experience with both kinds has led us to prefer the index style, as it can be read with more certainty under any circumstances. O. J. BUSHNELL,
Chicago, Ill.

Technically, a direct-reading meter dial is a dial that reads without a constant. The advantage of a direct-reading dial under this definition is obvious, since it obviates the necessity for multiplying the reading of the dial to obtain the billing amount. This is a great advantage, achieved only with some difficulty, but it now characterizes the whole of our production. It is so important and desirable that we have striven for two years to achieve it without introducing mechanical defects. I think, however, that the question does not relate literally to direct-reading dials, but rather to the cyclometer type of disappearing-figure dials. The direct-reading index dial is distinctly preferable to the cyclometer-type dial, for mechanical reasons. The cyclometer-type dial has been extensively manufactured by several makers, but has practically been universally abandoned, as it has been found to introduce serious mechanical friction after a period of use, and to affect the accuracy of the meter materially in sustained service. This has been the experience of all large companies that have used it extensively.

CARYL D. HASKINS,
Boston, Mass.

***40.—Is it not desirable to do away with all constants on meters, even though we must pay more for the meters?***

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It is desirable.

W. T. OVIATT,
Bridgeport, Conn.

Yes.

F. L. SARGENT,
Malden, Mass.

Yes; I will not purchase a meter with a constant if it can be avoided.

W. J. GREENE,
Cedar Rapids, Ia.

It is extremely desirable to eliminate all constants on meters, and this is possible without increasing the cost of the meter. One manufacturer has succeeded in supplying two-wire, 220-volt meters of 40 amperes and without constants; each division of the first dial being equivalent to 100 watt-hours. These sizes will embrace over 90 per cent of all the meters in service. On sizes larger than the above, each division of the first dial is 1,000 watts. There is thus introduced a constant of 10 in the dial itself, without the said constant being printed on the dial face. This arrangement has been objected to by many companies on account of the liability of the bill computer's mistaking the latter dial for the former and rendering a bill one-tenth of the correct amount. This, however, should be readily detected, and the trouble can be obviated by the use of a constant 10 placed by the bill computer on his record sheet, if necessary.

GEORGE ROSS GREEN,
Philadelphia, Pa.

Constants on meters cause more trouble than almost any other feature in the collection department of a central station, and they should be eliminated.

ANONYMOUS.

It is unquestionably desirable to do away with constants on meter dials, but this should not be done as it has been in some makes of meters, by changing the value of the dials in the larger-sized meters, which is almost sure to result in confusion and in some cases consequent loss to the company. It is better to have constants than to change the value of the dials. In the larger sizes of meters, doing away with the constants would necessitate the addition of higher dials, but this could be accomplished without much extra expense.

O. J. BUSHNELL,
Chicago, Ill.

By all means; the figures on the lowest-reading dial to read in kw-hours for all sizes. The result of these changes will be: Less chance for error; universal understanding of the meter system throughout the operating force, from the meterman to the cashier, and the removal of a great deal of doubt from the minds of consumers.

J. H. PERKINS,
Youngstown, O.

It certainly is desirable to do away with all constants except what may be termed decimal constants;

that is, constants that only involve adding a cipher or two to the reading for very large-sized meters. It is scarcely feasible, for mechanical reasons, to do away literally with all constants on very large meters, because the gear ratio between the dial and the meter will be such as to menace the accuracy of the meter. With the exception of the so-called decimal constants, however, constants can be eliminated and have been in our production, and this without taxing the purchaser for the change. CARYL D. HASKINS,
Boston, Mass.

*41.—Which method of heating is more remunerative and practical for central stations; steam or hot water?*

Under many of the conditions usually found in the middle Western States, hot water heating would be preferable to steam heating, as the necessary range of temperature, and hence the heat losses for the operating system, would be considerably less. There may be conditions, however, where the interest and depreciation on the investment necessary to circulate hot water properly would offset the heat losses.

P. JUNKERSFELD,
Chicago, Ill.

*42.—What conditions determine the wisdom of hand stoking versus mechanical stoking?*

The conditions that determine the choice between hand and mechanical stoking are so varied that in deciding the question for any particular case we should consider: Difference in cost of labor, difference in fixed charges, difference in efficiency and price of fuel, also labor troubles and smoke nuisance.

Let us assume a boiler plant of four boilers running 10 hours a day, 300 days a year, and burning one ton of coal an hour each, which amount of coal could be fired by hand at a cost of 20 cents per ton. Let us assume that to equip each of these boilers with a stoker would cost $2,500 more than with a plain grate, and that the fixed charges would be:

| | |
|---|---|
| Interest | 5 per cent |
| Depreciation | 8 per cent |
| Repairs | 5 per cent |
| | 18 per cent |

This, for each stoker, amounts to $450, or $1.50 per day for 300 days, and in burning 10 tons of coal per day the expense for fixed charges would be 15 cents per ton. If one man at 20 cents per hour will attend to four stokers, the cost for labor and fixed charges will be 20 cents per ton or just equal to the cost of hand firing. We therefore conclude that, under the conditions assumed, the preference as regards labor and fixed charges, with the one system or the other, depends upon whether the amount of coal burned is greater or less than 40 tons per day.

If coal costs $1.00 per ton, and if mechanical stoking is 10 per cent more efficient than hand stoking, then in a plant of two boilers burning 10 tons each, the cost per ton for the two systems will be:

| *Mechanical Stoking* | | *Hand Stoking* | |
|---|---|---|---|
| Labor | .10 | Labor | .20 |
| Fixed charges | .15 | Fuel wasted | .10 |
| Total | .25 | Total | .30 |

If coal costs $2.00 per ton, the relative costs with one boiler will be:

| *Mechanical Stoking* | | *Hand Stoking* | |
|---|---|---|---|
| Labor | .20 | Labor | .20 |
| Fixed charges | .15 | Fuel wasted | .20 |
| Total | .35 | Total | .40 |

This means that under the assumed conditions of fixed charges, labor and economy, and running 10 hours a day, stokers are preferable when they are 10 per cent more efficient than hand firing if coal costs $1.00 a ton and 20 tons are burned, or if coal costs $2.00 a ton and only 10 tons are burned.

Other figures might be deduced in the same way by assuming that stokers are in use more or less than 10 hours a day and that the difference in economy is more or less than 10 per cent. Aside from the possibility of saving money, there are often other considerations that enter into the case. A boiler-room employing a large amount of ignorant labor is an attractive proposition for the labor agitator. It is also impossible in such a boiler-room to prevent smoke when bituminous coal is being fired by hand. It is, however, possible to install automatic stokers, which will neither strike nor smoke.

W. L. ABBOTT,
Chicago, Ill.

We have heretofore used hand-fired furnaces, supposed to be of the smokeless type, but are at present installing chain-grate stokers under all boilers in our station. We find that they are more efficient and they do not compel us to depend upon the disposition of the firemen for economical results. We find that we can get more capacity from our boilers, without greater strain, presumably on account of the heat in the furnace being constant. The fire is perhaps not so sensitive to sudden changes of load, but we have found it sensitive enough to meet all conditions. With these stokers we find less unconsumed carbon in the ash than with hand firing, and much less smoke. It is not possible to use this form of stoker with all grades of coal, but we find it desirable with all coal obtainable in Toledo.

E. J. BECHTEL,
Toledo, O.

*43.—Is it desirable to shorten the hours of firemen to increase their efficiency?*

In large plants an eight-hour shift of firemen is good practice; but in smaller plants, where there are two shifts, of course the added expense of another man or set of men generally means much more expense, with no better results so far as firing is concerned. It is sometimes beneficial in such cases to have two 10-hour shifts and one four-hour shift; then two firemen are in the room together for six hours a day, giving opportunity for doing much work that could not otherwise be attended to properly.

R. J. PATTERSON,
Waterville, Me.

Shorter hours are advisable when the work is continuous and heavy, as mortal man can stand only so much.

E. H. JENKINS,
San Antonio, Tex.

The expense of a fireman is more in the cost of the fuel that he wastes than in the wages that he receives. The fireman doing an ordinary day's work will burn, say, eight tons of coal worth $2.00 per ton, amounting to $16; he will be paid $2.00 a day for his work. The boiler efficiency in an ordinary hand-fired plant does not average over 50 per cent, whereas on test conditions the same fireman will sometimes get an efficiency as high as 75 per cent—an improvement of 50 per cent over his ordinary work; and this 50 per cent, if it could be maintained, would amount to $5.33 per day.

It is not to be expected that the very best results will be obtained day in and day out, but if the fireman were given less work to do, shorter hours and a rest in the middle of his shift, his work would be materially improved; and while it might be necessary in some cases to add one or two men to the payroll, the saving on the coal account would more than offset this additional expense.

W. L. Abbott,
Chicago, Ill.

It is advisable to work firemen on hand-firing furnaces eight hours in preference to twelve, especially in summer-time, as so much depends upon the fireman's condition and disposition. The fireman is in a position to waste or save a great deal of coal. We have made this change, but can give no figures to verify our opinion. The work of the firemen, however, as well as the condition of their fires, speaks well for it.

E. J. Bechtel,
Toledo, O.

### *44.—Are steam turbines desirable for central-station work?*

Responding to your urgent invitation, and for the benefit of the twenty-fifth convention of the National Electric Light Association, I submit you some practical information relative to the operation of the turbo-generator outfit installed at the works of our company in Hartford.

This turbine is the largest ever built in one integral part. It is direct-connected to a revolving-field generator, rated by the manufacturers at 1,500 kilowatts; the same occupying a floor space, over all, 33 feet 3 inches in length, 8 feet 9 inches in width, and weighing 175,000 pounds.

The machine runs smoothly and requires no foundation bolts. The foundation for the same is comparatively inexpensive, requiring in this case 32 cubic feet of concrete and costing, complete, about $300. In this particular case more concrete was required than would be ordinarily used, owing to the fact that the foundation stands on made ground.

The turbine is equipped with two bearings, one at each end, running in a bath of oil. This oil is artificially cooled by forced circulation through coils of pipe submerged in water, which is afterward used for the feed for the boilers.

The speed of the turbine is 1,200 r.p.m., and it contains approximately 31,000 blades, about 16,000 of which are moving blades varying in length from one and three-fourth inches at the high-pressure end to eight inches below, at the low-pressure end. The diameter of the spindle at the high-pressure end is two feet; at the low-pressure end, seven feet two inches. With this design it admits of the full expansion of the steam. The full boiler pressure is admitted to the turbine in puffs at regular intervals, regardless of load. The puffs are either of long or short duration, varying with the variation of the load. At full load the puffs merge into an almost continuous blast. There is no variation of angular velocity which necessarily exists in reciprocating engines; consequently, the turbine runs very smoothly in parallel with generators driven by our water wheels. As there are no rubbing surfaces, no internal lubrication is required; it therefore allows the use of a high degree of superheat.

This turbine has been running but very little; only for the purpose of making tests to satisfy us as to its reliability, efficiency, etc.; we having had abundance of water power to operate our station for the past year.

A test made recently by our electrical engineer, Professor W. L. Robb, under the usual working conditions, gave the following results:

Consumption of steam, quarter load, 28 pounds per kw-hour; coal, 2.7 pounds per kw-hour.

Consumption of steam, half load, 23 pounds per kw-hour; coal, 2.1 pounds per kw-hour.

Consumption of steam, three-quarter load, 20.3 pounds per kw-hour; coal, 1.9 pounds per kw-hour.

Consumption of steam, full load, 19.1 pounds per kw-hour; coal, 1.7 pounds per kw-hour.

The average vacuum during the test was 27 inches.

The average superheat during the test was 30 degrees Fahrenheit.

The average steam pressure, 155 pounds.

Comparing these figures with an indicated horsepower of a reciprocating engine with a direct-connected generator of the same capacity, we figure that the coal consumption would be approximately as follows:

Quarter load, 1.77; half load, 1.33; three-quarter load, 1.25; full load, 1.12.

This test was made with no special firing (using Maryland bituminous coal), and under normal working conditions; it was therefore against rather than in favor of the good showing of the turbine, owing to the small leakages that invariably exist in a power plant of this capacity. This outfit, being rated at 1,500 kilowatts, will safely run 2,000 kilowatts continuously, as we have demonstrated in the time we have had the turbine in operation.

The supply of steam for this test was furnished by two Aultman and Taylor boilers, one of which is equipped with a superheater designed to superheat the steam 90 degrees Fahrenheit; this was mixed with saturated steam and the above results were obtained.

When this turbine was shipped to us from the Westinghouse Machine Company, it had never been run on a vacuum or with superheated steam; therefore, when it was installed in Hartford and started under the present conditions, it was found necessary to adjust the position of the blades to balance the thrust, and to make other minor changes suited to our conditions.

The machine in question has created a great deal of interest, as evidenced by the number of visitors from all parts of the world who have called and inspected our plant, and by the many questions we have been called upon to answer. We pride ourselves that we can produce an electrical horse power at a cost as low as, if not lower than, has been accomplished heretofore with a unit of this capacity.

ROBERT W. ROLLINS,
Hartford, Conn.

Steam turbines, when properly developed, as compared with reciprocating engines, give promise of lower first cost of prime mover and generator, very much less space occupied, less attention required and lower operating and maintenance costs. These points can be demonstrated only by actual experience, but if they are attained steam turbines will, of course, be highly desirable for central-station work, as many of the factors now entering into the actual cost of producing electrical energy will be correspondingly reduced.

P. JUNKERSFELD,
Chicago, Ill.

The question whether or not steam turbines are desirable units for central-station work, is answered by the number of such machines that are under construction.

The builders of the Westinghouse steam turbine have an aggregate of over 30,000 kilowatts under construction, in sizes ranging from 300 kilowatts to 5,000 kilowatts.

Their economy, as has just been shown by Mr. Rollins' remarks, is remarkable; particularly at the light loads. It may be said, generally, that the steam consumption at half load is but 10 per cent greater than at full load.

The most desirable conditions of operation for turbine work are:

*First*—A fairly high boiler pressure.

*Second*—A good vacuum; because the turbine is capable of utilizing the expansive energy of the steam down to the utmost limits of exhaust pressure. Between 26 and 27 inches of vacuum generally means a saving of six per cent in steam consumption in favor of the higher vacuum.

*Third*—The use of superheated steam. There are no rubbing surfaces inside the turbine where the parts are in contact with the steam, so there are none of the objectionable features that are sometimes incidental to the operation of reciprocating engines with superheat. Experiments seem to show that for every five degrees of superheat there is a gain of at least one per cent in economy. Guarantees of economy have been given as low as 11.7 pounds of steam per electrical horse power. This, note, is *electrical* and not *indicated* horse power. These guarantees, of course, were given under exceptional conditions of operation, which was for 165 pounds' boiler pressure, 29-inch vacuum, and 180 degrees of superheat.

With reference to space occupied by turbines, it would be hard to express it at a certain amount per kilowatt. A 400-kw outfit occupies a space of 19 feet long by 4 feet 6 inches wide, and its maximum height is 7 feet 6 inches, including the direct-connected generator.

A 750-kw outfit, to run at 1,500 r.p.m., and built in two cylinders, one compounded with the other, and having a reheating receiver for reheating the steam in its passage from one cylinder to the other,—such a machine occupies a floor space of 36 feet long, 8 feet wide, and has a maximum height of 7 feet 6 inches, including the direct-connected generator.

A 1,000-kw outfit, of similar description, is about 42 feet long, 8 feet wide and 8 feet high.

Regarding costs: It is my very good fortune to have nothing to do with the selling of turbines, and I am therefore unable to say much on the subject. I might mention, however, that a turbine can compete in price with a first-class reciprocating engine.

There are some other considerations, however, in the matter of foundations. All that is required is something to hold up the dead weight of the machine. As was pointed out by Mr. Rollins, the cost of a foundation for a 1,500-kw outfit was about $300.

The essential working parts of a turbine consist of little more than a shaft revolving in two bearings. These are amply flooded with oil, and the bearing pressures are low, and we do not believe that the journal actually comes in metallic contact with the bearings at any time. At all events, turbines that have been in operation many years have shown no wear whatever in the bearings; in fact, the tool marks have not even been rubbed off.

The steam velocities made use of in the Westinghouse turbine are comparatively low. They do not exceed about 600 feet per second, and it has been found that the turbine blades do not wear.

This type of turbine has not been in operation a sufficient length of time in this country to enable us to make any statements of cost of maintenance, but there is no doubt that such costs are exceptionally low.

FRANCIS HODGKINSON,
Pittsburg, Pa.

## DISCUSSION

THE PRESIDENT: Gentlemen, you have heard this paper; is there any discussion upon it?

MR. ABBOTT: I ask what vacuum he is able to get; that is, how much above the absolute.

MR. CAHOON: It is given here as 27 inches, average.

MR. JUNKERSFELD: May I ask the gentleman one further question? I should like to know if he has experienced any particular difficulty in running steam turbines at the speeds mentioned when the shafting is supported in two bearings only. It has occurred to me that on account of the large number of blades that are carried, and the considerable distances between the bearings, certain vibrations are liable to be set up in the shaft, which would seriously interfere with successful operation. It would seem that the question of deflection in shafting would not be the same as under ordinary conditions, on account of the different forces acting simultaneously. This is, of course, a question of design, but it is not likely to prove a troublesome one.

MR. HODGKINSON: I will say, in answer to questions, that the vacuum you are able to get depends upon the condenser you employ. Until the advent of the steam turbine, people were satisfied to get along with a 25-inch vacuum, and thought it preferable for the benefit of the extra temperature imparted to the feed water. With the steam turbine has come a demand for higher classes of condensers, which is being responded to by reputable builders. A 28-inch vacuum is considered excellent practice. Some people talk about 29 inches, but I do not think this is practicable. With a steam turbine, the vacuum should not be less than 27 inches.

MR. ABBOTT: Is it possible to get a higher vacuum with a steam turbine than with a reciprocating engine?

MR. HODGKINSON: Not necessarily. Good reciprocating engines are built with the glands having a small annular space into which live steam can be admitted, so that any leakage that may occur past the rods will be a little live steam rather than air leaking in, which would impair the vacuum. As to difficulties that would be encountered in having a large shaft carrying numerous rows of blades mounted on two bearings, I would say that such difficulties exist if the shaft is not strong enough, or has too much deflection, when there might be whipping, etc.; and that is one reason why we have considered it desirable in designing large turbines to divide the turbine into two parts, high pressure and low pressure. This, however, is only a question of design, and such difficulties are eliminated by keeping the shaft strong and permitting a minimum deflection.

**45.**—*What is the efficiency, cost, space required and maintenance expense of steam turbines?*

This question has been answered under the preceding question, No. 44.

**46.**—*Why should not coal be sold at a price compared with its ability to do work; its worth to be determined by a commission appointed to test its quality and frequent tests made to insure receiving the article paid for?*

I do not fully understand this question, but if the idea is to have the dealers not only guarantee to furnish you 2,000 pounds of coal, but guarantee also that the coal will contain a certain number of heat units, I think it would be a good thing. As it is now, the buying of coal is somewhat of a lottery.

F. Ellwood Smith,
Somerville, Mass.

We do not believe such a system would be practicable, for the reason that so many elements enter into the cost of mining and marketing coal. There are cases where coal is mined under many difficulties, and freight rates are excessive, so that, in spite of the quality, the coal company is obliged to charge as much for a product that may be only of medium quality as it would if it were the very best.

CHAS. H. PETERS,
Durango, Col.

The *selling* price of coal must be based primarily on its cost to the miner or shipper. There is no reason why *purchases* of coal should not and can not be made on the basis of calorific value. This can often be best stated in cost per million B. T. U. Necessarily, with a variation in freight rates, the cost per million B. T. U. will vary for the same coal in every market, on account of the difference in freight. Another point must not be neglected, and that is to compute calorific value of coal, not in total heat, but in effective heat. On the eastern coals, the difference between effective and total heat will not vary to any marked extent, but when you are comparing a bituminous coal with a lignite coal, the variation may be considerable. Some of the western lignites contain 20 per cent water and this means a loss for every pound of water, if fuel gases are discharged at 500 degrees, of 152 B. T. U. to raise water from 60 degrees to 212 degrees; 966 B. T. U. to supply the heat of vaporization, and 138 B. T. U. representing heat contained in water vapor between 212 degrees and 500 degrees. Ordinary flue gas has a specific heat of only about .235, while water vapor has a specific heat of .48. A lignite coal having 20 per cent moisture and a total calorific value of 10,000 B. T. U., will have an effective value of but 9,749 B. T. U., besides reducing your flame temperature, which will, in turn, lessen your boiler efficiency.

ANONYMOUS.

*47.—What is the best method of protecting high-tension transmission lines from lightning?*

This question is fully answered in the papers and discussions on protection of long-distance transmission lines, page 273 *et seq.*

*48.—What effect will lightning have on transmission lines operating synchronous apparatus?*

With single-phase apparatus it always breaks the phase and generally burns out one or more coils of the generator. This has been our experience, and we have discarded the apparatus.

C. E. BURROWS,
Walla Walla, Wash.

*49.—How may storage batteries be protected, operating in connection with induction or synchronous apparatus, when interruptions occur on the transmission line?*

Storage batteries may be protected when operated in connection with induction or synchronous apparatus, and be prevented from discharging back through the same when interruptions occur in the transmission line, in several ways, depending on whether the machines are used for charging only, or whether they are to be used reversibly; that is, on useful discharge the energy from the battery converted back into alternating currents and fed into alternating systems. In the first instance, the ordinary underload circuit breaker, interposed between the charging machine and the battery, will protect the latter. A polarized relay circuit breaker or an underload circuit breaker of an ordinary type, will also meet the requirements. The polarized relay may be constructed with a permanent magnet, or the poles may be produced by an exciting coil connected to the battery terminals, as these give electromotive force in one direction only, whatever may be the direction of current flow.

The above-mentioned circuit breakers can not be used where the battery is to discharge back into the alternating line, passing through an inverted rotary converter or synchronous motor generator, since reversal of current direction in the direct-current side would cause the circuit to open. The method most suitable for this case—which is a somewhat rare one in practice—is to make a spring-controlled circuit breaker to open the battery circuit, the latch being held in by the tongue of a small motor which receives current from the alternating transmission line and which is similar to the alternating voltage regulator of the General Electric Company. Those familiar with this device understand that the armature does not rotate continuously but simply exerts a torque. The regulator mentioned is a reactive device, the torque being merely incidental and not in any wise useful; but a very small apparatus, made on the same lines and excited from a transformer such as is used in connection with station voltmeters, could be made to operate the circuit-breaker latch; nor would the complete combination be expensive nor as complicated as the foregoing would indicate.

It may be added that the batteries would not greatly need protection in any case, as they would drive the converter or motor generator as a motor, and the counter electromotive force would prevent abnormal current flow; in fact, the current discharged by the battery would be only that necessary to drive the machine operating at no load, and the consequent energy loss would simply be that due to the friction and internal losses of the translating machine.

LAMAR LYNDON,
New York City.

In regard to the protection of storage batteries, I should say that if the object is to protect the battery, then it can be best protected either by fuses or by some kind of circuit breaker having a time limit. It will not do to have the storage battery thrown out of service by an instant overload, even if this overload amounts to many times the capacity of the battery. On the other hand, we can not afford to overload the battery for any length of time with such a heavy short circuit that it would warp the plates. In the latest installation of this kind made by the writer we protected the battery with copper fuses rated at about twice the one-hour discharge rate of the battery. This saved the battery, which had about 200-kw capacity, which otherwise would have had to carry about 1,000 kilowatts. The person asking the question may have had in mind more particularly the protection of the apparatus than the protection of the battery. A serious trouble has occurred where a storage battery has been used with rotary transformers, with the result that the rotary transformer when running with a light field acted as an inverted rotary and ran away. When there is almost unlimited power in a battery, this may mean the destruction of the rotary unless it can be cut out of circuit. There are two ways of avoiding this: The first way is to have the rotary excited by the exciter that is belted to the rotary or direct coupled to it, so that the field of the rotary will strengthen as the speed increases and prevent running away. The other method is to have the same kind of centrifugal speed-limiting device attached to the shaft of the rotary, so that at a certain speed an electrical contact is made which automatically opens the switch controlling the rotary and puts it out of circuit.

R. H. PIERCE,
Chicago, Ill.

**50.**—*What is the cost of maintenance and depreciation of storage batteries?*

It is impossible to answer this question clearly without stating a large number of conditions. We would say in general, however, that we assume that under average conditions (if there be such) the positive plates should last three or four years; if they last four years, then the annual cost of maintaining the plates would amount to 10 per cent of the original cost of the plates. To this would have to be added the cost of making the changes of plates, which would depend on circumstances. If the plates lasted three years this would make the depreciation equivalent to 15 per cent.

These figures ought to cover all depreciation. Of course, the cost will be different where a battery is used for railway work, or used to its capacity for doing heavy lighting work, and where it is used simply to float on the line in connection with lighting work. My statement is based on what I should figure the central-station manager would have to be prepared to face under average conditions.

As regards the maintenance, this depends upon the location of the battery—whether or not it can be inspected by a man who is also doing other work; and maintenance in the sense of putting the battery in good condition is covered by the item of depreciation. My figures would probably not be accepted by the battery men. One battery in this town is guaranteed at six per cent maintenance for three years, but we do not consider that a three-years maintenance guarantee amounts to anything. The best way to find out what the maintenance of a storage battery is, is to see what the makers will guarantee on a 10-year contract under the actual working conditions. We have installed a battery under these conditions where the maker agreed to maintain the battery for about five per cent of the cost of the plates and tanks, but this is probably too low for anything like the average condition.

R. H. Pierce,
Chicago, Ill.

The cost of maintenance and depreciation of storage batteries is a question that can not possibly be answered without complete data as to the size of the battery, the work that it is doing, the quantity and density of the electrolyte, the character of the plates, and the minimum voltage at which it is allowed to discharge.

If the battery is used for regulation, alternately charging and discharging at intervals not widely apart, the plates should have a comparatively thin layer of active material and, for a given quantity of active material, should have a considerable area exposed to the action of the electrolyte. If the batteries are to be used for storage purposes, being charged full during the hours of light load and discharged on the peaks, these same conditions should hold, provided the rate of discharge is rapid. On the other hand, if the rate of discharge is comparatively slow, a thick layer of active material will be more suitable.

Generally speaking, if a battery conforms to the following specifications and limits of operation, the maintenance and depreciation should come within nine or ten per cent:

1. Rate of charge or discharge never to exceed 12 amperes per square foot of active surface; the active surface to be considered as the length multiplied by the breadth by two of each of the *positive* plates. The factor two is introduced to cover both sides of the plate.

Of course, this is only an average value, applicable to most of the usual types. There are, however, batteries for which the rate given may be exceeded with safety.

2. The temperature at which they are operated never to exceed 100 degrees Fahrenheit.

3. The density of the electrolyte not to exceed 1.24 when battery is fully charged.

4. The quantity of electrolyte to be not less than 10 pounds per 100 ampere-hours of battery capacity.

5. The electrolyte to be pure and to contain no metals or lead-dissolving acids.

6. The density and quantity of the electrolyte always to be maintained at the original values.

7. The battery never to be permitted to discharge below 1.85 volts per cell, the reading being taken when the normal current rate is passing, or 1.80 when the discharge is at the maximum permissible rate.

It will be seen that there are a number of conditions, but they are no more onerous than those required in the successful operation of any dynamo-electric machine.

It may be noted that the difficulties which have attended battery operation in this country have arisen largely from an attempt to perform work with too small a battery. Increased battery capacity not only reduces the depreciation and cost of maintenance, but increases the efficiency to a marked extent.

The question of proper quantity of electrolyte also does not seem to have received the attention in this country which so important a factor deserves.

In addition to the requirements mentioned, the others, which are usually understood, with reference to prevention of excessive overcharge, not allowing the cells to stand uncharged in the electrolyte, cleaning out the sediment in the bottom of cells, etc., are also understood.

I regret very much that I am unable to go more thoroughly into the subject, but trust that the foregoing may prove of some interest to the members.

LAMAR LYNDON,
New York City.

***51.**—What is the relative heating effect of alternating and direct current upon lead-covered cables?*

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There is relatively no difference.

This question involves a great deal, and the person seeking the information would undoubtedly be pleased if all sides of the question were taken up. It is to be presumed from the question that a single-conductor lead-covered cable in an iron-pipe conduit has been used for alternating currents.

If a simple rule be followed there will be no heating whatever; namely, the outgoing and returning cables of all alternating circuits should be inclosed in the same lead sheath; for instance, a single-phase alternating circuit should have a twin cable inclosed in one lead cover. A two-phase circuit can be considered as made up of two single phases, or, if operated on the three-wire system, then all three wires should be within the same lead cover; the three-phase circuits should likewise be in a three-conductor lead-covered cable.

With direct currents there is absolutely no heating in the lead or iron-pipe conduit. With the outgoing and incoming wires of any alternating circuit assembled in the same sheath, there will be absolutely no heating. Therefore, there is no heating effect of either alternating or direct current when installed as above explained.

CALVIN W. RICE,
New York City.

***52.**—What breakdown test should be demanded of manufacturers of transformers for 2,000 to 2,500-volt distribution where secondaries are to be grounded?*

A 10,000-volt alternating-current pressure should be enough between primary and secondary coils and between coils and core and also between coils and case.

E. H. JENKINS,
San Antonio, Tex.

The insulation test that we apply to transformers for 2,000-volt circuits is 10,000 volts for one minute between primary coils and core and primary and secondary coils. We think this is a thoroughly safe test, and transformers of a lower standard than this should not be used. F. O. BLACKWELL,
Schenectady, N. Y.

### DISCUSSION

THE PRESIDENT: Mr. Kelsch, the question has been asked, "What do you think would be the proper insulation in case you wanted to ground your secondaries?"

MR. KELSCH (Montreal): When we used the standard insulation of two and one-half times the working pressure, we found the transformer to be a better lightning arrester than the devices that are generally used for that purpose. For the last two years we have bought transformers with a breakdown guarantee of 12,000 volts, and when we installed these we found that the lightning arrester broke down instead of the transformer, and believe that it pays to have the high-voltage breakdown test that we insist upon.

THE PRESIDENT: Do you mean, Mr. Kelsch, that you require the 12,000-volt breakdown test on the secondary winding?

MR KELSCH: Yes; we require an all-around breakdown test of 12,000 volts. We consider that the insulation on the secondary coils should successfully withstand this test, for the reason that it is possible for the primary wires of a foreign company to fall on our secondary wires. There are several companies operating in Montreal. I believe that the same high breakdown test should be required that is required on the primary coils, and it is required on the primary coils to prevent the primary coils from breaking through to the core or secondary coils. Let us suppose that the primary coil breaks down and comes in contact with the core of the transformer. Now, then, here is a condition where the insulation on the secondary coil must also successfully withstand the high-voltage test, to prevent the primary current from reaching the secondary winding and the customer's premises.

MR. HOLMES: I ask Mr. Kelsch if that requirement is for transformers with or without oil.

MR. KELSCH: We use the oil-type transformer. The test is made dry; the oil is only intended for cooling purposes.

### *53.—How may the butts of hard pine poles be preserved?*

THE PRESIDENT: I would suggest that perhaps good results might follow the use of a band of tar around the pole, extending two feet below and one foot above the ground. If the tar is green when you set the pole, dust it with lime and it will not come off on anyone's clothes. This treatment in a measure prevents rotting at the base line. The idea is not to tar the whole base of the pole, but to leave the bottom open for the free movement of the sap out of the bottom.

### *54.—How may oil stains be best removed from marble panel boards?*

With regard to the removal of oil stains from marble panel boards, I would say that, while we have never succeeded in entirely removing such stains, we have greatly improved the appearance of one of our boards by rubbing chalk over the surface, covering the same with blotting paper and applying a hot flatiron to the blotting paper. H. T. HARTMAN,

Philadelphia, Pa.

Oil stains may be removed from cloth by laying two or three thicknesses of blotters on the spot and putting on top of this a hot flatiron. A large portion of the oil is drawn into the blotting paper by capillary attraction. By finishing off with a sponge wetted with pentane or gasolene, the spot may be entirely removed. I should be inclined to attempt to remove spots from a marble switchboard in the same manner.

ANONYMOUS.

***55.**—I should like to have someone who is familiar with the subject explain the matter of "phase" and its various relations?*

No answer to this question was received.

***56.**—How low a pressure as between an underground cable and the ground is a dangerous factor in the matter of electrolysis?*

This question can not be answered in the form in which it is asked, for the reason that the destruction by electrolysis is not altogether a matter of pressure. A voltmeter may show considerable pressure between pipe and the ground circuit, and still there may be little electrolysis due to the high resistance in the path. In another case the pressure may be a fraction of a volt and still destructive electrolysis may take place. I should not dare set any absolute limit and say that it was safe.

R. H. PIERCE,
Chicago, Ill.

## DISCUSSION

THE PRESIDENT: Are there any further comments on this subject?

MR. BOTTOMLEY (Bellows Falls, Vt.): Mr. President, we have with us to-night a gentleman who is undoubtedly perfectly able to answer that question, and with your permission I should like to ask Captain William Brophy, of Boston, to say a few words on this subject.

CAPTAIN BROPHY: I believe the electrolytic effect on water pipes and lead cables was first discovered in Boston. By actual experiments, placing a section of lead cable in moist earth, it was found that electrolytic action would take place with one-tenth of a volt, and I am satisfied that it will take place with a much lower voltage. I do not know that I care to go into the matter any further, but the conditions surrounding the cable, the character of the duct, and many other things, tend to increase or decrease the amount of electrolytic action taking place on lead cables.

MR. H. H. SCOTT: A difference in the pressure does not always account for the electrolytic action. It depends a great deal upon the nature of the ground; the ground itself must be an electrolyte.

MR. WILLIAMS: Is it not true that under the conditions described, where current flows; however small the quantity, the electrolytic action follows?

The amount of this action depends, I understand, upon two factors: the volume of current flowing, and the property of the material through which it is passing.

Captain Brophy: I think that unless the cables are laid in rock, or rocky ground, electrolytic action will take place, particularly in the vicinity of the power station of street railways, under any circumstances. In the early days, when this subject was first taken up on a set of cables owned by the telephone company in Boston, we took from the surface of these cables a current of 500 amperes at a pressure varying from one volt to four volts in the immediate vicinity of the power house.

*57.—Is it necessary to connect an independent cable that shall return the current to the power house, or will grounding of the cable at frequent points eliminate the danger from electrolysis?*

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I take it that the object of this question is to ascertain whether or not it is necessary to have a cable in the return circuit in addition to the rail circuit. In most cases a return cable is practically useless, for the reason that any cable ordinarily used has resistance that is very high in comparison with a well-bonded track. To illustrate: experiments show that the resistance of iron in the form of bonded rails is eight to ten times that of continuous copper conductor. Taking the worst figure, and assuming that it is 10 times, then a 90-pound rail will be as good a conductor as a 1,000,000-cm cable; a track of two rails will equal a cable of 2,000,000 circular mils, and a double track one of 4,000,000 circular mils.

In putting in a new system, I should ordinarily install it without any cable to reinforce the rail circuit. I should then make a careful study of the losses in the return circuit and the voltage between pipes and grounds, noting both the amount and voltage, and the direction of the current; if the results were not then satisfactory I should put in copper at the points where it would do the most good. In general, I should say that a proper bond and grounding of the wires will give much better results than a haphazard installation of return copper.

R. H. PIERCE,
Chicago, Ill.

## DISCUSSION

MR. DUSMAN (York, Pa.): The question has arisen in our town as to what we shall do to remove the difficulty with electrolysis on the water and gas pipes. The gas company told me to connect their pipes to the rail, but the water company would not permit this. I should like to know the practice in different sections of the country, if there is any established custom.

THE PRESIDENT: I would say that if I represented the gas and water people I should not want you to connect my pipes to the rails; but I might allow you to connect my pipes at the power house to the negative side of the generators, with a conductor of low resistance. The trouble from electrolysis comes when the current leaves the pipes, not in going to the pipes. The electrolysis takes place where it leaves the pipes—at some joint where there is a high resistance—and the current is apt to cause trouble at the point where it leaves the pipe to get around the joint.

CAPTAIN BROPHY: I do not agree with the answer to the question as to grounding the cable. We have tried it in Boston, and it has proved utterly useless. As to the efficiency of return cables, that has been demonstrated beyond a doubt. Return cables are used on every line, and their efficiency has been demonstrated by reducing the current between the rail and the water pipes, lead cables, and other metallic substances under ground. You can at all times, in any system, find a difference of potential between the rails and the water pipes or gas pipes. I should not advise a connection between the rails and a water pipe or gas pipe, but the cables, etc., should be connected to the negative side of the 'bus-bars of the power station. I do not care where you go, or to what city you go, you will find a difference of potential between earth and rails. There is no city where there is a railroad track running parallel with the cables under ground where you can not find current flowing over these cables. We have had several gas explosions take place in manholes where there was nothing but telephone cables. This could not have been due to the current flowing in the conductors in these cables. So many of these explosions occurred that I made tests and found current flowing in considerable quantities over the surface of the lead covering. I also found a slight difference of potential between the lead of different cables, sufficient to establish an arc between them when separated and to ignite gas when present in the manholes. The vibration due to the passage of street cars and heavy teams in the street, caused these cables to separate where they were in contact, and the arc between them would ignite the gas and cause an explosion. This trouble can be overcome by making a firm electrical connection between the lead covering of all the cables in each manhole. Current does and will leave the rails of all electric-railway systems at distant points from the power houses, and returns again through the earth and negative side of the 'bus-bars, and at these points destructive corrosion, or electrolysis, takes place unless a path of low resistance is provided in the form of a cable or wires of ample size. One-tenth of a volt is sufficient, but the amount of corrosion is in proportion to current flowing from the lead to earth.

MR. CAHOON: Simply to second what Captain Brophy has said, I will say that I was manager of an electric railway and was also at the same time manager of the water company in the same city, and we found electrolysis going on. Although the road was thoroughly well bonded, we found four different places in the city where the pipes were beginning to be eaten away quite badly. I did just as Captain Brophy has suggested. I connected an eight-inch water pipe that ran under the electric-light station with a cable of very low resistance and carried that to the negative 'bus-bars, and the result was that, although we had a heavy return from the track to the station, we always got from 26 to 40 amperes shown on the amperemeter that I put in between the water pipe and the negative 'bus. We went over the track very carefully and double-bonded it, and thought we had the question of electrolysis thoroughly settled, but until we made the connection with the negative 'bus-bar we found that was not so. We subsequently, in order to protect the water pipes further, sectioned out the railroad and ran feeders back to the station, and we found that this helped matters materially. After we ran the cables back we often got no current showing on the ammeter between the water pipe and the negative 'bus.

It was my intention to contribute a paper on the question of explosions of gases in manholes, which would have been in line with what Captain Brophy has said, but unfortunately I was called away and was unable to write the paper. It was my intention at that time to bring out the very point that Captain Brophy has brought out, that many of the explosions of gases in manholes and in conduit systems were due entirely to the static charge that existed on the cable, which was set off, if I may use the term, by the jar of heavy wagons and of cars jumping on and off bad joints. That seems to be about the most feasible explanation that we can give of these explosions in manholes and conduits; we can not otherwise account for them. I have seen so many instances where explosions have occurred without any sign of a person being around or of the manholes being touched in any way, that this is the only explanation that can be offered. We have had two or three pretty bad ones in New York recently that were caused, I am convinced, by just these conditions—that there was a static discharge in some of the underground cables and it was set off by some jarring.

***58.**—What is the efficiency of various types of step-up and step-down transformers?*

No answer to this question was received.

***59.**—What is the best method of determining actual depreciation?*

Charge "operation" or "maintenance" monthly or yearly, with an amount equal to what depreciation is estimated to be; credit "depreciation fund" with such amounts. Whenever any part of the equipment is abandoned, scrapped or sold, charge "depreciation fund" with the original cost price less salvage, and credit "equipment" with the same amount. Whenever a piece of apparatus is rebuilt, charge "depreciation fund" with such cost of rebuilding less enhanced value, due to improvement, and credit "equipment" with the same amount.

W. J. GREENE,
Cedar Rapids, Ia.

While there is always an actual depreciation in all parts of an electric-lighting plant, yet the amount of this depreciation is always a matter of opinion, and it is practically impossible to find any way to say what the actual depreciation is. Depreciation is always estimated, and should always be estimated, by someone experienced in that work and familiar with the apparatus or material under consideration.

I may say that the most usual method adopted by other manufacturing industries is to assume a certain percentage, which shall be deducted from the book values as they stand at the end of each financial year. This method has been used for a great many years by American industries, but is one which I consider rather crude and do not in all cases approve of, as it is apt to reduce the profits rather more than is necessary.

The foreign method of amortization could well be adopted in this country, and may be described somewhat as follows:

During the early stages of the existence of a plant an estimate is made of the probable life of the different parts of the plant, dividing it into, say, real estate and buildings, steam plant, electric plant in buildings, distribution system and installation. In stating the length of life of these different parts, it is essential to take into consideration, not only the wear and tear, which is principally made up by the repairs, but the estimated loss due to improvements in the art, such, for instance, as the discarding of the whole system of arc lights of the old open-arc style and the installation of some newer system, such as the inclosed arc. When these ages or periods of life are determined, an amount of money is deposited to a renewal fund annually, which, placed at compound interest, will amount to the first cost of the apparatus or plant at the end of the period of life that is set for that apparatus. This amount can be determined from any annuity tables, but attention is called to the fact that while the ordinary annuity table begins at the time that would correspond with the installation of the plant, a table should be used that begins at the end of the first year of operation. Tables of this nature can be found in Matheson's "Depreciation of Factories," published by Spon and Chamberlin. Thus, at the end of the period when a machine is supposed to have been entirely worn out, there is an asset or fund in bank ready for the purchase of a new plant to take the place of the old and worn-out one.

It will be found that instead of charging off five per cent to profit and loss, as would be done under the old system, it will take but about three per cent to replace the apparatus in the same length of time, and a cash asset is always available for renewal purposes, should any part of the plant be rendered useless before the period of life expires.

In making up an estimate of a period of life of the different parts of a plant, attention is called to the fact that real estate usually appreciates, and this should be given consideration. Buildings depreciate very slowly if well constructed, and machinery will always sell for something, even though rendered useless or very inefficient as compared with newer machinery; and this "scrap value," as it is called, should be given consideration in reducing the amount that may be required to replace the same plant when it becomes necessary to renew.

HORATIO A. FOSTER,
Philadelphia, Pa.

## DISCUSSION

MR. ISAAC B. SMITH: Mr. Greene's answer to the question regarding depreciation was that a certain annual percentage of depreciation should be assumed to take place on each piece of apparatus, or class of apparatus, or equipment or construction constituting the entire plant. The amount thus determined should be credited monthly or periodically to "renewal fund," and a corresponding charge should be made to "operating expense." When any piece of apparatus, or part of construction or equipment, is abandoned, "renewal fund" should be charged with the cost price less salvage of that part of the plant abandoned. The result of this will be that, if the rate of depreciation determined upon has been ample, "renewal fund" will stand as a credit. If not ample, it will become a debit. In the course of time, whether the account stands as a credit or a debit, the result of the effect of the conditions that go to make up depreciation can be determined by a mere glance at "renewal fund."

THE PRESIDENT: The man who asked this question wanted to get at the rate of depreciation—what the assumption would be.

MR. ARTHUR WILLIAMS: I should like to ask what, in the opinion of the association, is a fair rate of depreciation, especially with reference to isolated plants.

THE PRESIDENT: I might call your attention to that part of Mr. Crowley's paper that bears slightly on this subject. He gives the different rates of depreciation for certain classes of apparatus.

MR. ABBOTT: It is my opinion that electrical apparatus depreciates much faster than we realize. This is due, not so much to its wearing out, as to its becoming obsolete. I do not think that apparatus that has been used in the business for the last 15 years has an average life of over six or eight years. I find that in making an estimate for depreciation my figures are always higher than those of anybody else. Perhaps this is because I have been in the business longer than most other people who figure on this depreciation. I know the stuff I bought 15 years ago became scrap in about five years. Of course, the depreciation is not so rapid now as it was then, but I think that during the first few years of its use, at least, there should not be less than 15 to 20 per cent depreciation, and after that the depreciation will be correspondingly less.

MR. ISAAC B. SMITH: It seems to me that this is a complicated question. I know the percentage of depreciation we have adopted varies from two per cent up to ten per cent, depending upon the apparatus. On the power house many companies consider that two per cent is a fair depreciation. Another consideration should probably be taken into account, outside of actual wear and tear and outside of the fact that the apparatus may become out of style, so to speak, and that is, whether it decreases or enhances in value. I think the last few years have actually shown an increase in the value of your electrical apparatus—I do not care whether it is old or new. If you adopt any particular system you will find that you have a complicated problem. It is hard to control this matter with any degree of accuracy; you had better guess at it, to start with, and see how you come out.

MR. CAHOON: I want to take issue with Mr. Abbott a little on the question of making the depreciation 15 per cent for the first five years of the use of electrical apparatus. I think that would have been perfectly true of electrical apparatus in the past, but I do not think it is true of the electrical apparatus that we are buying to-day. What we are going to charge to-day for depreciation, is what the gentleman who asked that question wants to know. The question of depreciation is a new one, comparatively speaking. It was the custom of many companies in years gone by to let depreciation look after itself, and they have run along, declaring dividends when they could, and have all at once met the issue that their apparatus was obsolete, or had gone to pieces and had to be replaced, and there was no depreciation fund with which to meet this expense. I think the English method of setting aside a definite amount for depreciation, and placing that fund at interest, is better than any of the methods we have adopted in this country. They find that by setting aside a certain percentage for depreciation they can get along with a much smaller percentage than if they charge it off, as many of the engineers in this country have recommended; that is, five per cent on certain pieces of apparatus, and carry it along at five per cent for the whole period of its life. Then, certain engineers have recommended that if we set aside five per cent for depreciation it should not be literally put aside—put into a bank—but should be considered a fund against which should be charged improvements and betterments, so that the value of the plant shall remain the same at all times. In other words, you keep your plant up to the same general level of efficiency that it had in the first place; the plant is always at 100 per cent. The method is, that instead of charging these improvements and betterments to your construction account, as is done ordinarily, you charge them over against this depreciation fund.

I think the better way to answer that question would be to take each piece of apparatus of to-day, the modern piece of apparatus, and estimate its life; and then we should estimate what rate of depreciation, when it is placed in a fund, set aside annually—we will say at three per cent—what amount at that rate of interest will equal the original cost of the apparatus. I think that if we carried that through for each class of apparatus — engines, boilers, dynamos, buildings, lamps, lines, etc. — we could arrive at a pretty fair estimate of what the depreciation would be; and I think this is a subject on which the engineers should come to some definite understanding. I think it is well worth their while to take this subject up and thresh it out. We do not want one engineer to say that it should be 10 per cent, and another engineer to say it should be three per cent, and another to say we should not have any depreciation account anywhere. The increase in the value of the property, as time goes on, and the increase in our output and income, will be, I think, such that we can take care of the future anyway; that is the view that many take. I have had some well-known engineers make this remark to me, and I have taken issue with them very strongly. They do not put aside anything at all.

MR. ISAAC B. SMITH: Would you recommend

investing money at two per cent? Would you not rather reinvest it in your own plant?

Mr. Abbott: To illustrate further what I meant in my previous remarks, take the case of a new direct-connected unit costing $100,000; generator connected to reciprocating engine. The next year after this is installed we may find that we can get a turbine unit of the same output, as economical as the reciprocating engine, for, say, $70,000. I think it is quite proper to write off at once for the first year $30,000 for depreciation—or 30 per cent. After that, depreciation will not be so rapid.

Mr. Arthur Williams: I raise this question because it seems one of great importance to central-station men. Many engineers allow nothing for the depreciation of prospective plants, on the ground that repairs and renewals offset any depreciation. This can not be the case, as one will quickly realize when remembering the tremendous difference between the selling price of second-hand machinery and its original cost. Depreciation must be allowed for in some manner and at some rate; the latter, either *pro rata* from year to year, or in any single year, as may be chosen; and it is important to have a consensus of opinion upon this point. A similar question was raised at the Boston annual meeting of the American Institute of Electrical Engineers, and the feeling at that time, I think, was that 10 per cent upon the cost of an electrical or mechanical plant was a fair depreciation charge. In New York eight per cent is used, allowing the plant about 12 years of useful life; it would be something more where a sinking fund was created, but this is seldom, if ever, done.

It should be remembered that depreciation takes place in several ways. The machinery wears out; or there comes a time when, even without wearing out, it can be profitably replaced with new machinery; there is also the ever-increasing competition of the central-station service. It will be conceded, I think, that the depreciation upon a plant reaches 100 per cent as soon as it can be replaced efficiently and more profitably by any other form of service.

MR. LEONARD ANDREWS: This is a question that we have had before us in England for some time. We have an association of municipal electrical engineers, the managers of municipal stations, and during the last few months we have been discussing this question of depreciation pretty fully. A few weeks before I left England we had a meeting of practically all the members of our association, and it was almost unanimously agreed that if we set aside about three per cent per annum for depreciation we should be meeting all that is necessary. Of course, we do not depreciate in England at quite the same rate that you do here; we do not scrap our plants quite so quickly. I thought you would be interested in this statement.

MR. CHARLES R. PRICE: I agree with Mr. Williams; for instance, when it comes to the substitution of incandescent arcs for the old open arcs, it practically throws our machines, which cost two and three thousand dollars, into the scrap heap, where they may possibly bring $100. Ten to 15 per cent is only a safe depreciation charge per annum on some departments of the plant.

MR. McCABE: I would ask Mr. Cahoon if he charges the betterments each year up to maintenance and operation. The plant not remaining the same, but its value increasing, why should he charge off any amount to depreciation? It is only a question of whether or not you charge the whole thing to maintenance and operation. If you charge your betterments to your actual plant account, then, of course, you have to offset that amount of depreciation. But if you do not offset that, your plant is always increasing; the value of the plant is increasing.

Mr. Cahoon: I do not know that I understand that exactly, but I think I can see what the gentleman means in a general way. That is, if he takes the betterments ordinarily put into a plant from year to year and, instead of charging that off to construction account, charges it into maintenance and operation, he is, for all practical purposes, maintaining his plant at 100 per cent.

Mr. McCabe: That is the idea exactly.

Mr. Cahoon: I want to make a reply to Mr. Abbott's statement in regard to charging off a $100,000 plant $30,000, because some turbine comes up to replace the ordinary reciprocating engine. I do not think that is doing justice to the plant. The difference in efficiency between the steam turbine, so far as we know at the present time, and a first-class reciprocating engine, is not great enough to warrant that amount being charged off. I do not think any plant can stand such a heavy charge being made against any one year. I think that if it is desirable to charge that off it should be charged to a suspense account and distributed over five years; otherwise you knock your dividends all to pieces and the stockholders make objections; and a small plant can not stand it, anyway.

Mr. Bottomley: While on this subject of depreciation, I will say that, unless I am very much mistaken, the Board of Gas and Electric Light Commissioners of Massachusetts, when estimating in their annual returns the cost of lighting municipal plants, add in as a factor of the cost of lighting the sum of five per cent on the total capital invested, as a depreciation fund.

MR. WILLIAMS: Mr. Chairman, I desire to propose as a resolution that, in the judgment of this association, it is proper to allow not less than 10 per cent annually as the depreciation account upon the cost of electrical and mechanical apparatus in private electrical plants.

MR. McGEE: As I understand it, if our plant is worth $100,000 when it is installed, at the end of one year it is worth $90,000. Suppose we put in improvements to the value of $5,000; are we to place the value of the plant at the end of the first year at $90,000 and take 10 per cent from that the next year?

MR. WILLIAMS: If a plant has cost $100,000 and $5,000 worth of improvements have been added during the first year, the total cost becomes $105,000; and at the end of the first year you should write off 10 per cent upon that sum, as representing the depreciation upon the private plant.

MR. CAHOON: I think that while we are on this subject we ought to cover the question of depreciation in central-station plants pure and simple, and I would make an amendment to Mr. Williams' motion that a central-station plant should not charge off less than seven and one-half per cent.

THE PRESIDENT: Pardon me, and allow me to make one remark. I believe it would be unsafe for us to take action on this matter without more mature consideration. When we say not less than 10 per cent on isolated plants, I think we are safe; but this depreciation problem is a nightmare with many of us, and we have to "sit up" with it all night long.

MR. CAHOON: This question was threshed out at the meeting in Boston, to which Mr. Williams referred.

THE PRESIDENT: I read what they had to say, and did not agree with them. If we are to take action, we should refer this question to a committee and go into it exhaustively and have some figures to back up our action. We want something to substantiate any action we take. You are free to make the motion and take any action you see fit, but, personally, I should like to see the thing gone into thoroughly by a committee, so that we could substantiate any action they might take.

MR. WILLIAMS: The private plant is in a different class, and the same conditions do not apply to it that apply to a central station.

MR. GILLETTE: I ask if a distinction should be made between boiler and engine room, or if they should be classed as a whole.

THE PRESIDENT: I think they should be distinct. Each piece of apparutus should be distinct.

MR. CAHOON: Speaking of private plants——

MR. GILLETTE: I had reference to central stations.

THE PRESIDENT: I think there are no two classes of apparatus that will depreciate at the same rate. In my opinion, there are no two makes of apparatus that will depreciate at the same rate.

MR. GILLETTE: In my experience, depreciation has been more rapid in the boiler room and the pipe room—in the steam end of the plant—than in the dynamo room, where proper care has been bestowed on that end of the plant.

(The motion of Mr. Williams was carried.)

### *60.—What special system of rates is best suited to water-power plant?*

No hard and fast rule can be laid down to fit all cases. The determination of the best system must be made after carefully considering all the elements in each case, and as these are endless in number it becomes purely a matter of local conditions, and should be so treated.

H. BOTTOMLEY,
Bellows Falls, Vt.

*61.—Can not a just freight rate be secured for the shipment of burned-out armatures and their return?*

The Committee on Amendments to Freight Classification of Electrical Apparatus and Goods is making a strong effort to secure more equitable freight rates for all electrical machinery, and hopes before another year to secure some marked improvement.

*62.—If a company is furnishing both electric light and gas, should one be pushed, or should both be pushed against each other; gas arcs against electric-arc lights, Welsbachs against incandescents, and gas engines against motors?*

With short-hour consumers with a large demand, push the gas side; with long-hour consumers, where the demand is not too great, push the electric side.

H. H. SCOTT,
Lincoln, Neb.

This question is somewhat unusual for an electric-light convention, but I think it deserves serious consideration, as it not only has a bearing on the proper conduct of those companies that are already operating both gas and electric-light plants, but it also has a bearing on the advisability of further consolidations. The ends aimed at in a gas and in an electric-light business do not differ greatly. One company supplying both classes of service can, if it wants to do so, supply them at a lower cost, give better service, and make more money, than could two independent companies. The business should be pushed with an idea of making the most profits, regardless of any wish to develop one particular branch of the business. I believe the best results can be obtained by pushing the gas business for intermittent lighting service and pushing the electrical business for long-hour lighting service. Welsbach lamps are not apt to give general satisfaction unless they are maintained by the company, either free or at a fixed charge per month. There is no particular advantage in pushing Welsbach lights where a gas and electric company have been consolidated. Gas engines are not apt to give the same satisfaction as electric motors, and the danger of competition is greater. It is a very easy matter to change over a gas engine to use gasolene, but an electric motor is generally so satisfactory that a consumer is not apt to attempt to obtain power in any other way. ANONYMOUS.

It depends entirely on existing conditions. If one department of the business is approaching capacity of works, push the other. If just building up a business, push both, giving consumer the choice. It is not necessary to disparage one or either; but give a black eye to gasolene and acetylene at every opportunity.

C. E. BURROWS,
Walla Walla, Wash.

THE PRESIDENT: I might add that, in view of our present knowledge of costs, I believe a very neat system of pushing a gas and electric-light business could be worked out to yield the maximum profits. There are certain electric-light consumers that are undesirable, and if we could so adjust our system of charging that they would be put on the gas side of the business—if both classes of business are operated by one company—it would result in a profit to the gas company and a saving in losses to the electric-light end of the concern. It would also be possible to make the gas and electric rates in such a way that a man with a large peak would take up the point of his peak with gas and keep an even load with electric current; and I think that is a matter that needs our further consideration.

MR. CAHOON: I do not want to take up too much time, but I want to call your attention to just that feature, which I put into effect in the city of Elmira, N. Y. I found we had a great many undesirable customers on the electric-lighting system. They were customers in residence districts covering a widely scattered area, and we had to use individual transformers, entailing, as you all know, quite a heavy loss on the lines. I divided the city into districts—the city being well adapted for that, as the business was all in one congested district, bounded by about four or five blocks in one direction and eight or nine in the other. I drew a circle around that district, and told the people in the business district that they could have electric light for 10 cents per kw-hour. When we got outside that district we doubled the rates. The gas consumption went up, and I more than doubled the number of connected lamps, carrying them from 6,600 to over 15,000, and we made both the gas and the electric-light service pay very well indeed.

MR. WILLIAMS: Did you find that the special rates in the one district affected your standing with customers in the other district?

MR. CAHOON: No; there were no bad results. The customers objected at first, but after they got the run of it, and saw the reason for it,—which we explained—that we could deliver a great bulk of current in the business district at a cheaper rate than to scatter it all over the city, they were apparently satisfied with the explanation. When they understood that, we had no further trouble. The people who wanted to use electric light in the residence district used it, and they paid double what they did in the business district.

MR. WILLIAMS: Taking the maximum demand as the factor, I think we get as good a load factor from residences as from office buildings. The office building has been looked upon as being a non-desirable customer, but I am of opinion that this is not the case; that if any building gives you all the light and power service it has, it can not be unprofitable. Within the past few days I have had occasion to look over some statistics relating to the supply of an office building in New York, finding that the net returns during the past twelve months averaged $5.00 for each 16-cp lamp installed, the charge being at the rate of 10 cents per kw-hour; of two hotels recently looked into, one had an average of six hours, and the other, enjoying a slightly lower rate, had seven hours' daily use for each lamp connected for the 365 days of the year.

***63.—What is the best practice with regard to underground distribution and connections to consumers' premises for system embracing both 500-volt direct current, 1,000-volt alternating current and direct-current series arcs?***

I consider this question rather an intricate one to answer, having no knowledge of the volume of the business and the territory it covers, and lacking a great deal of necessary information upon which to base an intelligent answer. First of all, I think I should simplify my system, supplying the outskirts of my city with alternating current of such a character as to meet the requirements for light, power, etc. In the centre of this lighting district it might be advisable to install a three-wire, direct-current system, 110 to 220-volt, for light, power and general uses. In my estimation the best plan of distribution for a direct-current system is to run three mains consisting of three cables on each side of the street, as close to the curb as convenient, making lateral connections to each building (in some cases one lateral may answer for two or more buildings). The connections can be made up in small handholes in the street. The lateral ends, or services, should be made up to a water-proof, cartridge-fused switch. The ordinary slate or marble-based switch is liable to corrode and cause trouble, owing to the dampness to which the switches are exposed. The mains referred to should receive the supply of current from junction boxes placed in sewered manholes, at points to give a uniform pressure and even distribution of load on the various feeders supplying current to the system.

If the gentleman who asked this question will come to Hartford and explain his conditions, I will gladly give him all the information in my power, which will no doubt be of more value than this, which may be wide of the mark.

This same system can be employed for alternating-current distribution, placing subway transformers in manholes for the supply of current. We place our inclosed primary fuses on a pole, adjacent to the manhole containing the transformer.

R. W. Rollins,
Hartford, Conn.

*64.—What is the best practice regarding the transposition of high-potential alternating-current lines one to fifteen miles in length?*

We are operating two 10,000-volt, three-phase, 60-cycle alternating lines, one of which is 10 and the other 13 miles long. No transpositions have been placed in either of the lines, and we have experienced no difficulty on account of induction.

E. H. Mather,
Portland, Me.

Our 6,600-volt alternating transmission of about five miles in length is not transposed at all. It is run on the old single-petticoat glasses formerly used for a direct-current arc circuit and shows next to no leakage in wet weather, and no line characteristic of a troublesome nature.

J. W. Cartwright,
Bangor, Me.

Lines of this length need not involve considerations other than the mechanical features. In a 15-

mile line of moderate power three transportations should give all the necessary flexibility. If such a line be made up of more than one circuit, then the transpositions should have some regard for the amount of power transmitted in each circuit, the voltage, phase and frequency, in order to compensate inductive effects between circuits. E. GRISSINGER,

Buffalo, N. Y.

The transposition of any line, whether long or short, high or low potential, is for the purpose of overcoming the evil effects of mutual electromagnetic induction. This mutual induction may result in interference with neighboring lines of the same class and character, or may result in interference with neighboring lines of an entirely different class. For example: many parallel lines running out from a station may act inductively on each other, the lines carrying high currents disturbing the potential on lines carrying low currents, and *vice versa*; or the lines from any station running parallel to telegraph or telephone lines may, by inducing current upon these neighboring lines, interfere with the apparatus connected with them. This mutual induction may be due to the electrostatic effect or the electromagnetic effect. So far as I am aware, no satisfactory cure has been effected of the electrostatic interference. The electromagnetic interference may be overcome by proper transpositions, and whether or not transpositions shall be placed in lines from one to fifteen miles in length, depends almost entirely upon the quantity of current these lines are carrying, the proximity of other lines, and the character of those other lines. Telephone lines running for one mile or more parallel to power lines are almost invariably seriously affected, and for these lines transposition should undoubtedly be introduced, either in the telephone lines themselves, or in the adjoining power lines. The telegraph apparatus, not being as sensitive as telephone apparatus, is not so readily affected, and cases are rare where the interference is serious where the lines are parallel for distances less than four or five miles; and, indeed, the problem of properly doing away with mutual induction between power lines and grounded telephone lines is one that has to be handled most carefully, since the ordinary method of transposition is generally unavailable to remedy the difficulty. Power lines carrying less than 100 amperes do not ordinarily interfere with each other to a serious extent where they are run parallel for less than two or three miles, but for greater distances or greater currents they undoubtedly do interfere and should be transposed. In one case that has been brought to my knowledge, where many lines carrying large currents were run out of the station for distribution to a city, being parallel in some cases for not more than 1,000 feet, the interference between the different power lines was so serious that pressure wires run back to the station gave no indication of the pressure at the terminals, since both the power lines themselves and the pressure wires were seriously affected by neighboring currents. Finally, it must be called to your attention that transpositions carelessly done, and without due regard to what a transposition is to effect, are of comparatively little value. I know of one line where the telephone circuit was transposed every eighth pole, and where not only was the telephone useless, but the bells burned out, although the power line was carrying but about 20 amperes. This trouble was remedied altogether by taking out these transpositions and putting in transpositions about one every 30 poles, but properly located with reference to the transpositions of the power line, which had not previously been taken into account. In order to lay out the transpositions of any line, it is necessary to follow in direction and amount the field of force surrounding the line itself. Single-phase lines are transposed simply as telephone lines by crossing them, since any two sections of equal length between which there is a cross have equal fields of force acting in opposite directions, and consequently neutralize each other. A barreling of a three-phase line rotates the field of force one-third of a revolution, and, in consequence, it is necessary to rotate the line twice before the individual equal sections neutralize each other, and in this case no two of the three equal sections between which there are transpositions neutralize, though the three are neutral when taken together with reference to any parallel line. The four-wire, two-phase line is only neutralized when there are three barrelings and four sections of equal length and the three barrels divide the line into four sections of equal magnetic strength. These four sections neutralize each other in pairs, but no two neighboring sections neutralize. The first and third neutralize each other and the second and fourth neutralize each other, but the first has no influence on the second or fourth, the second has no influence on the first or third, and so on. It is stated that the barreling of a line is necessary for neutralizing the effect of the earth upon that line itself, but, so far as I have been able to observe, no such effect is to be found; two and three-phase lines without any transpositions working as well as those that have been transposed or barreled, provided the three-phase wires are located at the corners of an equilateral triangle and the wires of each phase of a two-phase line at the diagonally opposite corners of a square. In transposing any line with reference to any other line, the transpositions should be introduced in sections where the current, and consequently the magnetic field, is constant. If this question of the constancy of the magnetic field and the effect of its direction, already described, be taken into account, all interference to or from neighboring lines is readily overcome. The question whether the lines carry high or low potential is, in my mind, not important with reference to transpositions, since the effect of high potential is to produce electrostatic induction, and this effect is not readily overcome by transpositions.

F. A. C. PERRINE,
Pittsfield, Mass.

## DISCUSSION

THE PRESIDENT: Is there any discussion on this question?

MR. P. M. LINCOLN: I ask for some expression of opinion as to how serious a matter this transposition problem is. My experience has pointed to the fact that most of the trouble on high-tension lines is due to static and not to dynamic induction. I have been told by others who have run high-tension lines that as long as they could keep the telephone and telegraph lines insulated from the ground, and overcome the static induction, they had no trouble from dynamic induction, although there is no transposition on telegraph and telephone lines.

MR. BERTRAND (Peoria, Ill.): We changed our voltage last summer from 1,000 to 2,000 volts. While that is not very high tension compared with the system that Mr. Lincoln represents, it brings out the point. We divided our primary current by two, but the effect on the city telephone lines was not to decrease the induction on their lines, but rather to increase it, which would point to static rather than magnetic inductance as causing the trouble.

***65.**—What is the best means of attracting new electric-light consumers?*

With us, the best means of attracting new consumers has been the reduction of rates. Each reduction we have made has within two months had the effect of largely increasing our gross earnings. If we could afford to stand the first reduction in earnings for a longer time we could put the price to a point that would enforce the use of electricity over any price that the gas company could make.

JAMES W. CARTWRIGHT,
Bangor, Me.

*First*—Place all lights and motors on separate generators and circuits.

*Second*—Make the regulation of the lighting circuits as nearly perfect as possible.

*Third*—Make the price as low as possible, allowing a reasonable interest on the capital invested.

*Fourth*—Present the advantages of the electric light to the public through capable solicitors.

E. H. MATHER,
Portland, Me.

The best method of attracting new consumers for electric light is to reduce the price of the service, if it can be done. The plan used by telephone companies, of giving three or four months' service free, has also been very successful, and is a method that would probably appeal to central-station men as being better than any permanent reduction of rates. If the former plan is attempted, it must be done with a good understanding of the conditions under which electricity is produced and used, or the effect might be disastrous. In the latter plan it is simply a matter of making a plain statement to consumers.

R. J. PATTERSON,
Waterville, Me.

Keep the voltage uniform, the lamps renewed often, and the customer's wants attended to before he finds them out if possible.

CHAS. E. SCOTT,
Bristol, Pa.

A perfect service at a reasonable price, and selling fixtures almost at cost. No matter how cheap light may be, if the service is poor it is very difficult, if not impossible, to increase your number of customers at a satisfactory rate. A good thing will sell upon its merits, and even if there be something a little cheaper but not so good, the best will in the end win out. By selling fixtures at almost cost you will often find two or three lights burning in a place where a single drop. light would have been made to answer otherwise. A well-lighted room is a standing advertisement by which the company will gain. Give a new lamp for every four or five dollars' worth of current consumed; this will insure the laying aside of blackened globes, and give the customer the candle power he pays for. Courtesy upon the part of all employees. Do not tolerate an insolent or discourteous man. Go after business as if you really wanted it.

CHAS. H. PETERS,
Durango, Col.

The best way to attract new customers is to make your old customers so well satisfied with the quality of the light and power, the reasonableness of the rates, and the honesty and courteous treatment of the local manager, that they shall proclaim to all their friends the satisfaction that they feel. This kind of advertising will give better and more lasting returns than any amount of talk or display by those whom they know to be directly interested.

H. H. TAYLOR,
Gardner, Mass.

## DISCUSSION

THE PRESIDENT: With regard to this question, I would say that about two years ago I had occasion to start a new central station. Instead of adopting any of the methods outlined in the answers to this question, I offered a premium to wiremen for every lamp wired up. In a town of 80,000 population, and where competition is strong, we have wired up 42,000 incandescent lights in two years. In Denver, Col., we have competitive conditions. The old central station, with which I am connected, reduced its rates the middle of last April. We have not made any very great efforts for new business, yet in April of this year our incandescent lighting was 93.5 per cent more than a year ago for the same service. The power sales have increased about 70 per cent in a year. Yet, strange as it may seem, what looked to be a big reduction in rates on power happens to figure out for the last two months only seven and nine per cent less than was formerly obtained for current. I think the increased sales are the most phenomenal I ever heard of in a central station that was considered as already fully developed. The funny part of it is that we did not intend to do it; we could not help doing it, and it has got us into a peck of trouble. Our construction account for this particular property has been running in the neighborhood of $25,000 per month to buy new meters, service wires, transformers, etc., and to take care of the increase in our electric and gas departments.

Mr. Williams: How did the business develop so tremendously?

The President: In the electrical department we did not encourage such a growth of the business, but we did in the gas department; and when I spoke of $25,000 a month for construction, that applied also to the gas department, where we had about 20 solicitors and increased the customers of the company about 50 per cent in one year. The electrical department was not giving as good service about a year and a half ago as it might have done, and the first thing we did was to put the whole town on a three-wire, interconnected secondary system, maintaining a voltage that was almost uniform, establishing a system of free lamp renewals, and reducing our rates to about 50 per cent of our consumers. The system of rates used is one of those systems where it is within the power of the consumers to fix their own rates, and some of them took advantage of the saving, while others have increased their consumption all the way from 100 to 150 per cent; in one case even to 900 per cent, and in several cases over 400 per cent.

The other plant referred to was a water-power plant. The premium paid there was 50 cents per lamp for consumers on a flat rate; 25 cents a lamp for consumers on another rate—the so-called Doherty rate; the rate described in the paper that I read before the National Electric Light Association—and five cents per lamp for consumers on the straight rate. We are developing the business very rapidly on this basis.

**66.**—*What is the maximum revenue obtainable from any city for electric lighting, stated on a per capita basis?*

From the statistics of 40 cities in New England, each of which has a population of 4,500 or over, we find the largest income *per capita* to be $6.64. This we believe to be a very exceptional case. We consider $3.50 the ordinary maximum revenue.

E. H. MATHER,
Portland, Me.

We have done quite a little figuring on this problem, hoping to be able to give you some information that would be of value. We found, however, that there were so many features, which varied between very wide limits, that any figure we could give would not be accurate within a very large percentage.

It is easy to estimate the size of power station required for a given population, as the capacities *per* *capita* do not vary very largely, but the cost of real estate, distributing system and other items outside of the power station proper, varies in Massachusetts from 25 per cent to 75 per cent of the total investment. The output of the plant varies in our companies from 28 to 78 kw-hours *per capita.* All these variations have a large bearing on the figure that we want to get at, and we find so many undeterminable factors that we fear we could not give any information that would be of value. STONE AND WEBSTER,

Boston, Mass.

*67.—What is the lowest rate at which electric current can be sold and net a five or six per cent profit on the capital invested, in a city of 30,000 to 50,000 population with the best bituminous coal at $4.00 per ton?*

---

I should say that the price at which electric current could be sold to net five or six per cent profit on the capital invested, under the conditions named, will vary so much with the character of the plant, the price of labor and the conditions of service, that I doubt whether it is possible to make an intelligent answer. The lowest rate at which we sell current in any of our plants is a cent and a half per kw-hour. In this case the load is fairly constant for 18 hours per day, and the minumum is over $16,000 per year.

We have some few long-hour day customers at two and a half cents per kw-hour, and with minima so proportioned as to insure us a reasonable return on the investment required to take care of the load. On the other hand, such customers as mills and factories, which use current for only six months of the year or less, and then for an average of not more than an hour per day at the peak of the load, can not be profitably carried at any price unless the station happens to have plenty of reserve capacity.

H. T. HARTMAN,
Philadelphia, Pa.

This is a very broad question, and I do not think it can be answered unless more facts be given. There is a very great difference in cities of 30,000 to 50,000 inhabitants, both as to the character of the inhabitants and the character of the business done, both of which affect the sale of electricity. A city very near to a large city is very different from a city of the same population standing by itself, and the amount of business done is very different.

I have compared the cities of Massachusetts having the population named, and the sales *per capita* range from $1.14 to $4.68, and the profits *per capita* from 17 cents to 131 cents. The rates charged vary from 20 cents to 14 cents net. The lowest regular price for incandescent-lighting current by any Massachusetts company is 11 cents. Of course, it makes a great difference whether the electric current is for incandescent lighting or whether it is for power; and, again, it makes a difference whether the power is for manufacturing purposes, to be used 10 hours a day, or for railway use, where it is used 18 or 20 hours per day. Current for power is being sold in Massachusetts at from ten cents to two and one-half cents per kw-hour, according to conditions. I should say that the average price for current for all purposes in cities from 30,000 to 50,000 population should not be less than 15 cents per kw-hour.

F. ELLWOOD SMITH,
Somerville, Mass.

*68.—In a large station, what is the best voltage of generators when about one-half of the current is for local distribution within a radius of five miles and the other half to be raised to high voltage for long-distance transmission?*

---

I would say that under the conditions named we recommend operating generators at the so-called 2,000-volt pressure, or, say, 2,400 volts.

DUDLEY FARRAND,  
Newark, N. J.

Our electrical superintendent advises me that, in his opinion, 3,300 volts would be the best.

HENRY A. PIERCE,  
Pawtucket, R. I.

In a large station, the load of which is divided between local service and long-distance transmission, the best practice as to generator voltage is undoubtedly that voltage which is best suited for the local service. For a radius of five miles, if the load is a large one, 4,400 volts may be required, while the degree of load may be such that 2,200 volts would suffice. For the long-distance service, step-up transformers would be necessary, and these would cost approximately the same whether the generator voltage were 400 or 4,000. It would be poor practice to use one generator voltage for local service and another for long-distance work in order to dispense with step-up transformers, for the reason that the flexibility of the station would be impaired.

E. GRISSINGER,  
Buffalo, N. Y.

**69.**—*Is it desirable to place high-tension circuits (10,000 to 20,000 volts) running from generating stations in country districts to sub-stations in cities, under ground within city limits?*

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This is being successfully and profitably done at St. Paul, Minn. Current is being transmitted under ground for a distance of three miles at 25,000 volts. One paper-covered and one rubber-covered cable are being used. HENRY L. DOHERTY.

**70.**—*Can converters supplying street-railway load be operated from three-phase or two-phase, 60-cycle, separately excited alternators, which are at the same time supplying a lighting load of incandescent lights and arc lamps? Will the pulsating load on the rotary cause a fluctuation at the generator beyond that which is occasioned by engine regulation? Can this be done with perfect success without storage-battery auxiliary, or some such arrangement, to take care of the wide fluctuations?*

---

The conditions controlling this problem are:

(a) Engine regulation,
(b) Generator regulation,
(c) Line regulation,
(d) Rotary characteristic,
(e) Ratio of fluctuations of railway load to total load.

To operate converters under the conditions specified:

(a) Engine regulation can not usually be safely made less than four per cent from no-load to full-load in order to insure proper division of load between generators.

(b) Generator regulation should be specified as six per cent or better.

(c) Line regulation should be perfect; that is, connection made to 'bus-bars by separate conductors for the converters.

(d) Rotary and transformers supplying it should have small inductance; rotary should have compound winding, so adjusted that it will have power factor of unity at 50-per-cent load. This will tend to compensate for the generator and engine regulation, by strengthening the generator fields.

(e) Suppose the load to fluctuate 50 per cent of the capacity of the unit in service, then the engine speed would fall two per cent and the generator voltage would be reduced three per cent, which, added to the engine drop, would make a total of approximately five per cent. Should the rotary be only shunt-wound, the effect of the lagging current would give a further drop in the generator voltage. Five per cent drop is too great a variation for good lighting service, but one-half of this, or two and one-half per cent, can be safely taken care of, which means that if the load fluctuations are not more than 25 per cent of the capacity of the unit or units in service, good lighting service can be given from a system that is simultaneously supplying railway load from rotary converters.

H. G. Stott,
New York.

## DISCUSSION

The President: We should like the members present to discuss this question.

Mr. Perkins: Representing the Youngstown Consolidated Gas and Electric Company, I believe that we have all the apparatus and all the conditions outlined in this question, including the storage batteries;

and while we know what to do to get along successfully, I hardly know what to outline as a general case, and I do not believe it can be done. Each case must be worked out on its own merits. I heartily agree with what has been read as a written answer to this question, and would lay more stress on the engine capacity; that is, the overload factor of the engine. It was a surprise to me, and, no doubt, a surprise to others, to hear that the rotary converters could be adjusted to make up for all ordinary engine regulation and all of the generator regulation. If the engine is made large enough to take care of the peaks, the engine and generator regulation will be taken care of by the rotary. Very fine operation can be obtained up to the point where the engine begins to lay down. The specification for this is, as the written answer states, that the rotary shall be compounded and that the field rheostat be set for a power factor of one at a 50-per-cent load. On lower loads, the rotary will give the generator a lagging current, which will tend to keep down the voltage that would naturally rise on taking off a load from both engine and generator. On loads greater than 50 per cent, the rotary gives the generator a leading current which tends to raise the voltage of the generator and to counterbalance for the drop in voltage that would naturally occur at heavy loads.

As to whether both light and power can be operated together, I do not think it can be done at all times. In another plant you might have changed conditions, and under certain conditions we can not operate in this way. During the daytime we are operating about 800 kilowatts in railway and 350 to 400 kilowatts in lighting and power. I do not believe we get any voltage variation of over two and one-half per cent, as shown in the written answer. At times of heavier engine overload, which are necessary for economy, we separate the lighting and railway by a double 'bus-bar system. If the rotaries are properly designed with relation to the engine and generator, I do not think there will be any fluctuations due to the rotary transformer, and I take it from the question that the party means "pumping" effect.

With regard to the storage battery: I do not think this has much to do with the more even regulation, except that it takes off the peaks that are too great for the engine; that is, it has no steadying effect. If the engine were considerably overloaded, the storage battery would save that part of the drop; but the regulation due to the rotary transformer is automatic, and does not require any assistance from the storage battery up to the point of great overload of the engine. We have storage batteries where I can see that there is no particular gain in better regulation, except that it takes off the peaks, which would be of advantage to make up for lack in engine capacity. Our engines are rated much larger as compared with the generators. Generators on railway loads, especially alternating current, will stand great overloads; but if you have not the engine to do the work, you can not get the regulation.

Mr. Charles F. Scott: There is one element that we have been leaving out in the discussion of the operation of such an alternating-current plant as is referred to in this question. We talk about the apparatus; but that is not the only thing. It requires the combination of a man who knows how to get the right kind of apparatus and knows how to operate that apparatus in the right way. The important thing—which Mr. Perkins did not mention—about the

Youngstown plant that is operating so well is Mr. Perkins himself.

*71.—How is the "Tub Transformer" for arc lighting regarded from the central-station standpoint?*

---

The chief advantage that occurs to me is that one machine can be used for both incandescent and arc lighting. By this method only one type of machine is required, and instead of having to purchase two types, two machines of the same type may be used, giving a spare machine, or one to help out in case of overload.

During the hours when the incandescent load is small, the arc load helps to bring up the total load, enabling the generator to run at a more efficient point than where two small machines are used each with a light load.

J. E. Barker,
El Paso, Tex.

# APPENDIX

## REPORT OF COMMITTEE ON PRESIDENT'S ADDRESS

*Mr. President and Members of the National Electric Light Association:*

Your committee appointed to report on the president's address takes pleasure in stating that, after giving the entire subject most careful consideration, it most heartily indorses the breadth and scope of the address, and the many novel and unique ideas contained therein, all of which it is sure will work to the benefit of the association if systematically carried out.

### APATHY OF MEMBERSHIP

The remarks on this subject are highly appropriate, and recall the fact that the work of large committees has been unsatisfactory through lack of concerted effort and that the ideal condition would point to individual responsibility and work of all the members. This does not mean that committee work can be entirely discarded, but that much of the work should be carried out individually, by appointment or election; the idea in its entirety to be to get more work from a larger number, thereby increasing the interest and responsibility of the general membership.

### PROGRAMME METHOD

The effectiveness of this policy as outlined above has been shown in a gratifying manner by the uniform interest and thoroughness of the discussions brought out in this meeting.

We recommend that thoroughly prepared discussions on the more pertinent questions submitted by members be assigned to competent persons, and that these discussions be supplemented by written answers from the membership in general.

We further recommend that other questions brought out by the question-box method be grouped by subjects in the discussions, to eliminate waste of time and to focus the attention of the association on the specific question under consideration.

### PROGRESS EDITOR

You will all agree with the president and this committee that in the past too much detail work has been expected of the president, and that he should have more time to devote to the general policy and to the direction of his assistants in the work of the association.

Further, as a part of the scheme for individual and concentrated work, we recommend the election of a progress editor, whose duty shall be to report at each meeting on the progress of the art, by subjects, for the year just past; this report to be brief and to the point, but with such information as will enable the individual members to take up more fully any one question, at their leisure.

Since the report of the nominating committee has already been made and officers elected, we recommend that the position of progress editor for the coming year be filled by appointment by the incoming president.

### AFFILIATION OF OTHER ORGANIZATIONS

We agree with the president that the affiliation and support of other associations similar to our own is highly desirable, and recommend that the secretary be instructed to extend to the officers of such associations a cordial invitation to attend our meetings.

We further recommend that the secretary be instructed to invite the technical heads of the various leading universities and colleges to attend the meetings of our association, and also to communicate with the faculty of such institutions, urging them to provide for the attendance of such technical heads or their representatives.

### METRIC SYSTEM

We recommend that this matter be made a subject for discussion at our next annual meeting.

### UNDERGROUND CONSTRUCTION

We recommend that Mr. Doherty's offer to award a gold medal to the contributor of the most comprehensive paper on underground construction be accepted, with the condition that there shall not be less than five contributors, and that the judges of such papers be appointed by the president.

### ADDITIONAL NOVEL IDEAS

In line with Mr. Doherty's suggestions on "Advantageous Work that Might Be Done by the Association," we recommend the institution of a Wrinkle Department, the editor of the same to be appointed by the incoming president, the editor in turn to appoint his editors or assistants.

We further recommend that the incoming president appoint a reporter on the following subjects:

Decorative Lighting,
Sign Lighting,
Office Methods and Accounting,

and a committee of one on lost and unaccounted-for current.

The recommendation for these latter appointments is made with the assurance that they will develop funds of valuable information regarding the matters referred to.

In conclusion, we wish to say that we have not tried to go into endless detail regarding these interesting questions, but that they will all appeal to you as being prime factors in increasing the interest in our meetings.

Respectfully submitted,

J. H. PERKINS, Chairman,
C. F. HEWITT,
R. S. KELSCH.

---

Upon motion, the report was accepted, and it was unanimously resolved that the recommendations of the committee be adopted.

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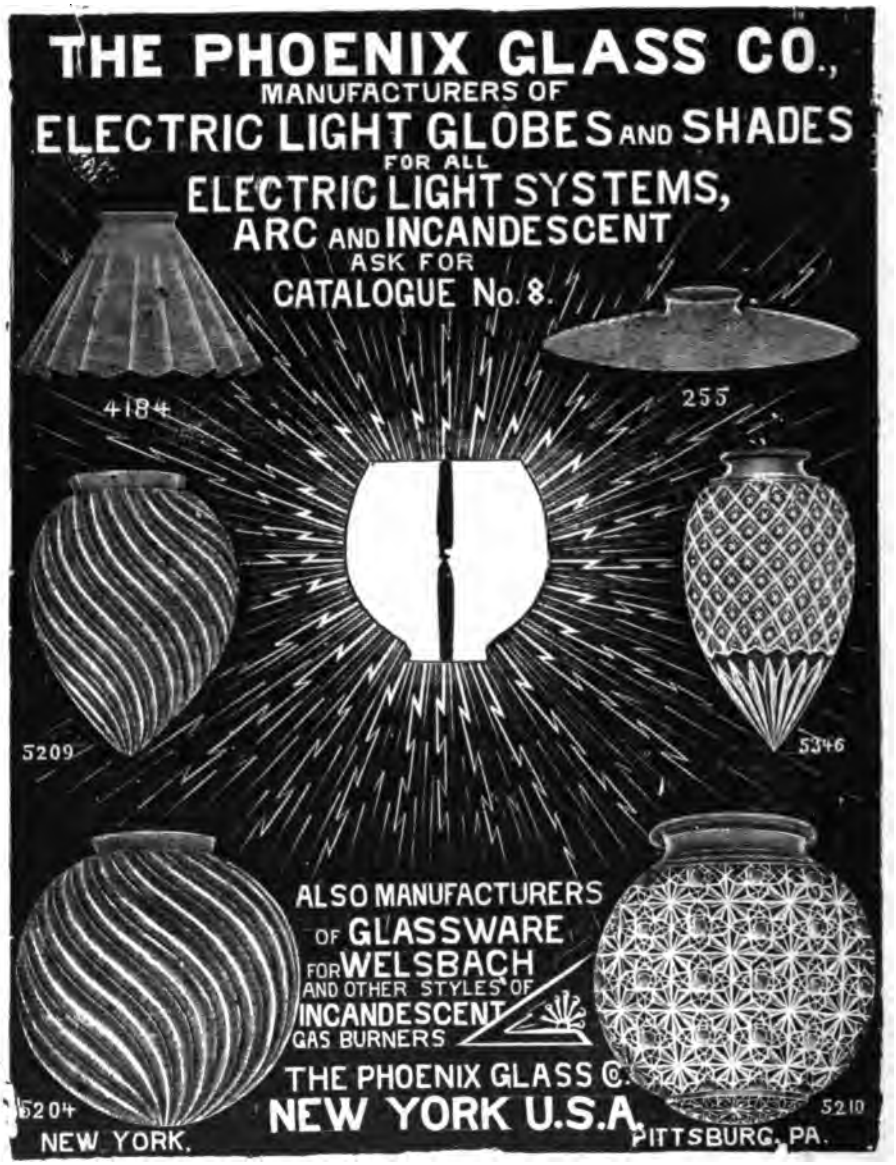

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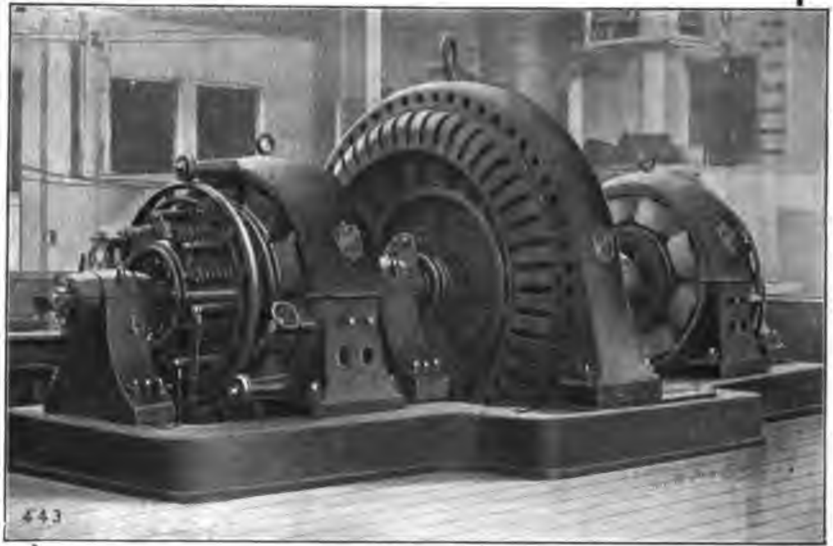

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